Vision 2008

VISION

The University of Montana
Research, Scholarship & Innovation 2008

Hidden Secrets of Bird Evolution

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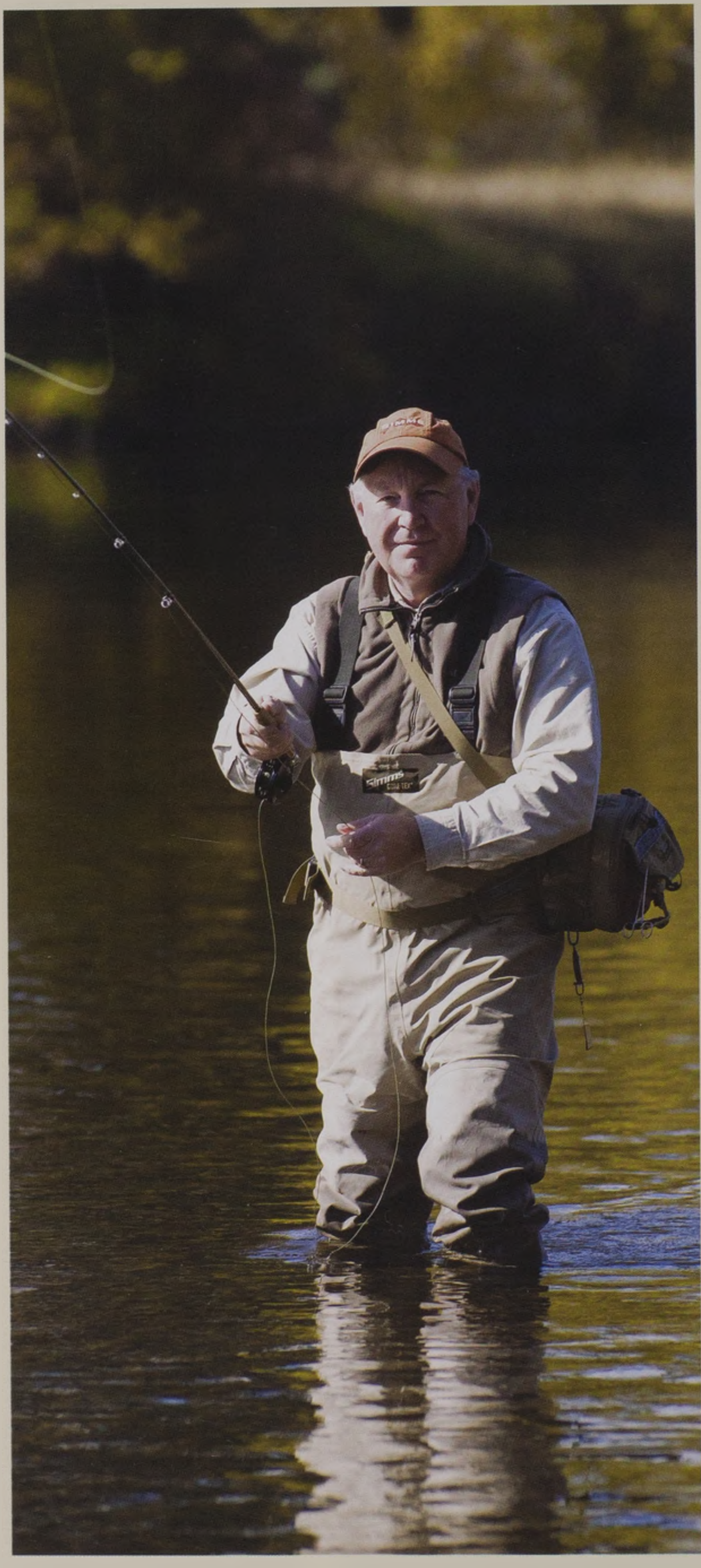
Cover: While studying how chukar partridges grow and develop the ability to fly, UM researcher Ken Dial developed an original theory for the evolution of bird flight.

Mark Bradley, Boreal Nature Photos

The Canadian caribou has become a creature of controversy, much like the northern spotted owl in the United States. Read more on page 16

Inner Vision



I'm fortunate to live in Western Montana. After a day in the office, I can disappear up a wooded drainage, wade into clear waters, cast my line and let the workaday world fade for a bit. I'm convinced that fly-fishing in fresh, pine-scented air focuses the mind and cures the soul.

Though only minutes from campus, I often see wildlife — deer, chipmunks, osprey, trout. I'm constantly amazed that I work at a university placed in the middle of a vast, largely intact ecosystem. Ours is the only place in the lower 48 where all the native mammal species noted by Lewis and Clark more than two centuries ago still roam.

It's been said so often it's almost a cliché, but The University of Montana and our world-class researchers are surrounded by a wonderful natural laboratory. Discovery is just out the back door.

One of my fishing partners, Dan Pletscher, director of UM's Wildlife Biology Program, puts it this way: "Other places read about it. We live in the middle of it."

UM has become a world leader for its research and educational programs in ornithology, wildlife and wilderness management. It hosts some of the nation's finest biological sciences, forestry and wildlife biology programs, including the Avian Science Center, Avian Flight Lab and Montana Cooperative Wildlife Research Unit — the latter of which was led for 25 years by John J. Craighead, a giant of the conservation movement who, along with his twin brother, Frank, pioneered grizzly bear research.

Short drives from campus, the University boasts treasures such as the Flathead Lake Biological Station and Lubrecht Experimental Forest. Even Mount Sentinel — the campus-owned mountain that serves as UM's spectacular backdrop — is studied for its role as an urban interface and battlefield for native and invasive plants.

So it is my privilege to offer this issue of Vision with a wildlife research theme. The eight stories herein offer a small but important slice of the excellent work being accomplished by our scores of campus scientists who study the varied creatures of our natural world.

The subjects in this issue vary from a new stationary instrument used to study the ranges of wolves to the fact that earlier springtime melts are leaving winter-white snowshoe hares revealed to predators. We had to include a story about the troubles facing trout, of course, as well as one about two researchers who in the same year received Early Career Development Program grants from the National Science Foundation — an unprecedented accomplishment at UM.

Though we love our backyard, University wildlife research makes an impact worldwide. One story examines a scientist studying caribou habitat in the Canadian Rockies, while another follows a UM researcher chasing egg-size variation among birds into South American jungles. And the magazine's cover story describes a new hypothesis for the evolution of birds that is transforming textbooks around the globe.

This University, amidst this natural laboratory, is a special place. We hope you enjoy this glimpse into ideas taking flight from here. V

Daniel J. Dwyer
Vice President for Research and Development
The University of Montana

UM scientists reel in research dollars

UM researchers secured more than $62 million in external grants and contracts for fiscal year 2008.

The top five recipients were:

- **Andrij Holian**, Center for Environmental Health Sciences, $3 million.
- **Jerry Bromenshenk**, Division of Biological Sciences, $2.9 million.
- **Jack Stanford**, Flathead Lake Biological Station, $2.8 million.
- **Rick Hauer**, Flathead Lake Biological Station, $2.4 million.
- **Mike Kavanaugh**, Center for Structural and Functional Neuroscience, $1.9 million.

UM President George Dennison says that funding attracted by campus researchers contributes substantially to economic development in Montana, supporting student projects and keeping scientists on the cutting edge of research and development.

Degrees offered with international partners

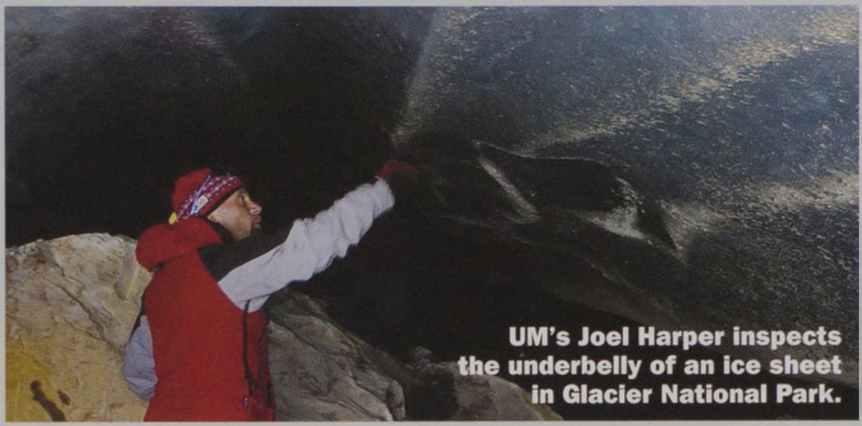
The UM Department of Geosciences, with partner institutions in Germany and Ireland, has established UM's first transnational dual and joint degree programs.

UM's first dual degree program is a Bachelor of Science in international field geosciences, offered collaboratively with the University of Potsdam in Germany. Students graduating from the program will receive two separate bachelor's degrees, one from UM and one from the University of Potsdam.

The University's first joint degree program is a Bachelor of Science degree, also in international field geosciences, offered in cooperation with University College Cork in Ireland. Students graduating from the program will receive a single degree that is jointly administered and awarded by the two universities.

"Although dual and joint degrees involving institutional partnerships are relatively commonplace in Europe, these shared degree models have not been widely implemented in the United States," says geosciences Professor Marc Hendrix, UM's principal architect of the new international programs. "The greatest advantage for students in these programs is that they benefit directly from the unique educational resources available at each of the partner institutions."

UM students seeking either of the new degrees are required to spend one year of overseas study in Germany or Ireland and engage in a curriculum that focuses on field-based geoscience learning with additional course work in natural science, language and cultural training. European students seeking either degree must spend one year of study at UM's Missoula campus.



John Newton photo

UM's Joel Harper inspects the underbelly of an ice sheet in Glacier National Park.

Glaciologist projects sea level rise

When Joel Harper talks about calving, it has nothing to do with cattle.

Harper, a UM glaciologist, studies the melting and movement of the world's ice sheets. For him, calving is what happens when ice sheets meet the ocean and break apart to form icebergs.

Now Harper and his research partners suggest there needs to be a whole lot more calving going on to make the direst climate change predictions of sea level rise — sometimes suggested at 6 meters or more — come to fruition by 2100.

In fact, glaciers and ice sheets would have to reach never-recorded sustained speeds to make the most extreme ocean level rises come true according to the researchers' new methodology, laid out in the Sept. 5 edition of Science.

The latest Intergovernmental Panel on Climate Change report projects between 18 to 60 centimeters (7.2 to 24 inches) of sea level rise by 2100. But Harper says that projection has come under criticism for not including ice dynamics — how ice sometimes speeds up and calves more icebergs in response to lubrication from meltwater or warming ocean temperatures.

"We simply don't understand the physics of ice dynamics well enough to make accurate model predictions," he says. "There are just too many uncertainties. So what we did is flip the problem on its head."

Admitting ice dynamics is an unknown, the researchers worked the problem backward. They asked, "What would the glaciers and ice fields have to do to produce 2 meters of sea level rise by 2100? How about 5 meters?"

"We found you would need to have phenomenal calving," says Harper, who has lived and worked on the Greenland ice cap the past two summers, studying the increased melting there.

He says for the Greenland ice sheet to produce 2 meters of worldwide sea level rise by 2100, the glaciers moving into the island's calving fjords would have to increase their speed to 45.8 kilometers (28.4 miles) per year and sustain that speed until the end of the century.

"For some perspective, the mean velocity right now is about 1.2 kilometers per year," Harper says. "So you would need a 40-something increase in the mean velocity. And this scenario includes increasing the surface melt rate by tenfold."

He says scientists have never seen ice move 45.8 kilometers per year anywhere in the world. "But we can't prove that it's impossible," he says. "What we can say is that it's not a good working hypothesis. Fifteen kilometers per year is the fastest we've ever seen one of the Greenland outlet glaciers go, and that one already stopped doing that."

So, armed with the new method for dealing with ice dynamics, how high do Harper and his partners think world oceans will rise by 2100?

"We think they will rise between .8 and 2 meters (2.7 and 6.7 feet)," he says. "That includes plausible ice dynamics scenarios."

However, Harper stresses that a rise of even .8 meters is a huge deal. Raising the California Central Valley levees only .15 meter, for example, would cost more than $1 billion.

Harper's partners in the study are Tad Pfeffer at the University of Colorado and Shad O'Neel at the University of California, San Diego.

University scientists help map edge of solar system

As our sun rumbles around the galactic core at 486,000 mph — taking us along for the ride — it constantly emits particles called the solar wind. At the edge of the solar system, 100 times farther out than the distance between the sun and the Earth, this wind dies down as it hits the hydrogen and helium gas between stars. Interstellar space, it seems, is not totally empty.

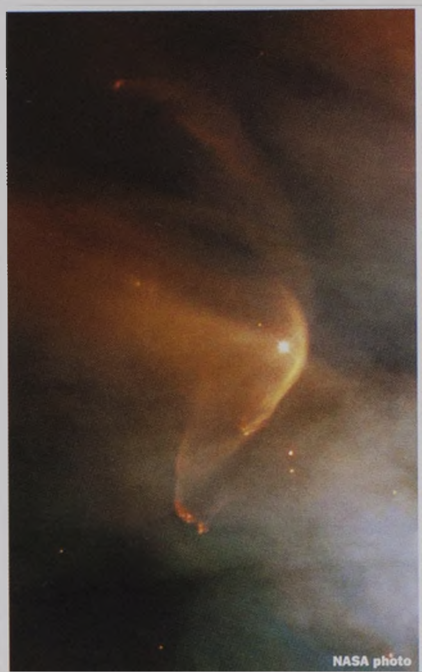
This edge region, the interstellar boundary, forms a vast teardrop-shaped bow shock around our solar system as the sun moves along its orbital path. It's not unlike a rock in a stream. Though astronomers have photographed the bow shocks around other stars, we know precious little about our own.

That started to change Oct. 19 with the launch of a NASA spacecraft called IBEX, the Interstellar Boundary Explorer. UM scientist Dan Reisenfeld helped design one of two primary instruments on IBEX, which will create an all-sky map of the interstellar boundary.

Both Reisenfeld and fellow UM researcher Paul Janzen are part of the core payload team for the spacecraft.

"It's been fast and furious," Reisenfeld says of the three years between project approval and launch. "It's exciting that IBEX is ready to get to work."

The spacecraft launched aboard a Pegasus rocket dropped from under the belly of an aircraft flying over the Pacific Ocean near the Marshall Islands. The Pegasus carried IBEX 130 miles above the Earth, and then a motor pushed the probe above low-Earth orbit.



A Hubble Space Telescope image of a crescent-shaped bow shock around a young star in the Great Nebula in Orion

"The spacecraft has a highly elliptical orbit that goes out almost to the distance of the moon," Reisenfeld says. "It's an eight-day orbit. The reason for that is it needs to get beyond the Earth's magnetosphere — this collection of energetic particles surrounding our planet — that otherwise will swamp our signal."

The two primary instruments on the 5-foot-wide spacecraft — IBEX-Low and IBEX-Hi — detect a range of energetic neutral atoms that are energized at the boundary of the solar system. Reisenfeld designed a section of IBEX-Hi that ionizes, steers and accelerates the particles to where they can be detected.

"Dr. Janzen and I have also been very much involved with the details of how the instrument will be operated in orbit," he says. "In addition, we have been planning how the data are going to be binned and sorted out and sent down to the ground, as well as the sequences of commands that are used to turn on and operate the instrument."

Besides answering questions about the size and shape of the bow shock and "heliosheath" surrounding our planetary system, IBEX also may answer questions about how that region protects us from interstellar cosmic rays.

Reisenfeld says these rays are intense radiation that can damage DNA or knock out electrical gear on satellites and other spacecraft. Mainly because of the heliosheath, only about 10 percent of cosmic rays reach the inner solar system, and then the Earth's magnetosphere offers another layer of protection that reduces the radiation further.

He says two NASA spacecrafts launched in 1977, the Voyager 1 and 2 probes, have reached the heliosheath on the border of interstellar space.

Reisenfeld became involved with the IBEX project while working at the Los Alamos National Laboratory in New Mexico. His boss and mentor at that time, Dave McComas, is now the IBEX principal investigator at Southwest Research Institute in San Antonio.

The IBEX proposal was submitted in 2004 as part of NASA's competitive Explorer Program. Five proposals were funded for a concept study, and then IBEX was finally selected to become a low-cost, rapidly developed Small Explorers spacecraft in 2005.

Reisenfeld came to UM in 2004, remaining heavily involved with NASA projects while teaching Montana students courses such as Modern Physics and Quantum Mechanics.

Research center earns grant to assist rural people with disabilities

A UM research center that works to improve the ability of people with disabilities to live independently in rural America has been awarded a five-year, $4.25 million grant from the U.S. Department of Education.

The funding went to the Research and Training Center on Disability in Rural Communities (RTC:Rural). Established in 1988, the center is part of UM's Rural Institute, which supports the independence, productivity and community inclusion of persons with disabilities.

"Some 56 million Americans live in rural areas, and nearly 20 percent of those live with a disability," says Tom Seekins, director of RTC:Rural. "While rural America is their home, living there can place them at a disadvantage compared to their urban counterparts."

Seekins says the grant will fund a sustainable plan for quality research and training that will continue to enhance state-of-the-art practices in rural disability and rehabilitation. It also will finance a variety of activities, such as evaluating rural health promotion strategies that could lead to improved employment outcomes, conducting a randomized controlled trial to evaluate ways to improve rural consumers' use of health care services or identifying strategies to improve rural transportation.

"We really believe this grant gives us the ability to improve the lives of rural Americans with disabilities," Seekins says.

The grant also will create a program to disseminate RTC:Rural's research findings and spark the use of evidence-based rural practices by policymakers, advocates, service providers and others.

RTC:Rural has made myriad discoveries in its field during the past two decades. For example, it learned that people with disabilities are self-employed at higher rates than the general population and that people with disabilities in rural areas have the highest rates of self-employment.

UM releases report on campus greenhouse gas

In response to growing concerns about the impacts of climate change, UM has completed its first-ever campus greenhouse gas inventory.

The 38-page report, available online at http://www.umt.edu/urelations/greenhouse.html, is an effort to detail and understand the carbon footprint of UM's central campus and College of Technology.

In February 2007, UM President George Dennison became a charter signatory of the American College and University Presidents Climate Commitment. By signing the agreement, Dennison pledged to make UM more sustainable, with the ultimate goal of neutralizing greenhouse gas emissions on campus.

The UM inventory is an initial step toward achieving that goal and will lead to a campus action plan to reduce greenhouse gas emissions. The report was submitted to the ACUPCC's online greenhouse gas reporting system on Sept. 15.

"In my view, this report illustrates quite well the campuswide commitment to sustainability and bodes well for the future of the University," Dennison says.

The inventory studied the years 2000 to 2007. During that span, UM emissions increased 16.4 percent. There are many reasons for the increase, including a growing student population and more campus buildings.

The report outlines how total campus emissions come from three main sources: on-campus steam production (36.1 percent), transportation (31.6 percent) and purchased electricity (30.8 percent). Solid waste contributed 1.3 percent of emissions, and fertilizer application added .2 percent.

Sustainability coordinator Jessie Davie

The inventory found UM emitted 42,690 metric tons of carbon dioxide at its two Missoula campuses in 2007. The average full-time UM student contributed about 3.8 metric tons in 2007.

The inventory resulted from a campuswide cooperative effort directed by Jessie Davie, the Associated Students of UM sustainability coordinator, with a full-time graduate student and four interns. This group was advised by Phil Condon, an environmental studies associate professor, and member of UM's Sustainable Campus Committee.

Davie and her partners started working on the report in October 2007.

Inge Rudbach accepts a plaque honoring her husband, Tony, from Montana Gov. Brian Schweitzer.

MonTEC laboratory named for energetic campus contributor

Tony would have been proud.

On Oct. 10, family, friends and colleagues of Jon "Tony" Rudbach gathered across the river from campus to dedicate a laboratory in his name at MonTEC, the business incubator Rudbach helped create in cooperation with UM and the Missoula Area Economic Development Corp. The many dignitaries at the event included Montana Gov. Brian Schweitzer, who said, "Tony brought together two worlds — science and economic development."

Rudbach was UM's associate vice president for research and development. He passed away Aug. 10 following complications from an automobile accident.

In the '70s and early '80s, Rudbach served as a UM microbiology professor for several years. During that time and the ensuing decades, he worked in the private sector with several companies, including his own consulting firm. Perhaps his crowning achievement was creating a test used worldwide that protects vaccines, drugs and other injected substances from dangerous endotoxins.

In 1995 Rudbach joined the Office of the Vice President for Research and Development, where he passionately worked to spur the Montana economy. He created and oversaw many projects designed to revitalize the economy of Eastern Montana and was committed to a project to spread business incubators across Western Montana. He also helped create a tech-transfer program that ensured both inventors and campus benefited from intellectual properties developed at UM.

Fire center develops new Web site

Summer in the Northern Rockies means camping, fishing, hiking and other activities on public lands. It also means an increased risk of wildfire, which can lead to restrictions and closures on those same areas.

Now through a new Web site, http://www.firerestrictions.org, the public can check on the restrictions and closures that are in place during the wildland fire seasons in Montana, Idaho, North Dakota and northwestern South Dakota.

The Web site is a cooperative effort between the Northern Rockies Coordination Group and UM's National Center for Landscape Fire Analysis. NCLFA uses science and technology to make wildland fire management more efficient and effective.

Invading honeybee virus discovered

UM researchers and their campus-affiliated company, Bee Alert Technology Inc., have employed a powerful new tool created by a U.S. Army lab to discover a honeybee virus invading North America.

The new virus does not cause Colony Collapse Disorder — a mysterious malady depopulating beehives around the globe — but the method used to find the virus may help scientists unravel the CCD mystery in the future.

The invading bee virus is called Varroa destructor virus-1. First definitively identified in Europe in 2006, VDV-1 is carried by both honeybees and the tiny varroa mites that afflict them.

The invading virus was discovered in two honeybee samples collected by UM scientists in the southeastern United States. Jerry Bromenshenk, a UM biology research professor, and his colleagues gathered the incriminating samples as part of a larger sampling effort in bee yards affected by CCD across the nation.

Bee Alert had the samples analyzed at the Edgewood Chemical Biological Center, a U.S. Army-backed laboratory based at the Aberdeen Proving Grounds in Maryland. Edgewood has developed a liquid-chromatograph proteomics mass-spectrometry device, which can identify all the peptides (short lengths of proteins) in a given sample.

"Every virus, every fungus, every bacteria has its own group of peptides that are unique to it," Bromenshenk says. "We provided bee samples from a wide area and a number of colonies, and they very quickly produced a fingerprint of every pathogen that the honeybees are carrying."

The Edgewood analysis didn't provide a smoking gun for what causes CCD, but it did reveal that a European bee virus had "jumped the pond," Bromenshenk says.

"What's significant about this is typically we don't know about new pathogens arriving on U.S. soil until there is some sort of outbreak and significant loss of colonies going around," says Colin Henderson, a Bee Alert employee and UM College of Technology faculty member.

He says an exciting aspect of Edgewood's new technology is that it reveals everything contained in a sample. Using typical genetics-based methods like the polymerase chain reaction laboratory method — the same type used in the 1990s O.J. Simpson trial — scientists must specifically target genes and match those with the sequences they are searching for. This is expensive and time consuming. The Edgewood method identifies all the peptides, which then are cross-referenced with an index of millions of peptides stored at the National Center for Biotechnology Information and other databases.

Building brings more lab space to UM

In a continuing quest to provide more modern laboratory space for University researchers, another science building is rising on the south side of campus.

Construction began on the 61,500-square-foot Interdisciplinary Science Building adjacent to the Health Sciences Building in the summer of 2007. The first phase of the project – the outer shell and first floor – will be completed by the end of fall semester 2008. The second phase – the second floor – should be completed during spring semester 2009. Additional phases have not been scheduled.

When completed, the building will cost about $14.7 million. It will include four research floors and a basement.

Charlie Janson, associate dean of the Division of Biological Sciences, says the new structure will provide improved lab space for externally funded biology and biochemistry researchers now housed in the Charles H. Clapp Building, as well as room for the new Center for Biomolecular Structure and Dynamics.

The first floor will contain a 120-seat lecture hall, a 30-seat computer classroom, a conference room, office space and more. The upper floors will each contain four research laboratories and offices for faculty, postdoctoral associates and graduate students. Plans for the basement include a teaching lab and room for high-tech instrumentation.

Janson says the name of the building may change if a generous donor comes forward with funding to help finish the research floors.

Study: Polluted city air may predispose children to diseases later in life

Exposure to severe air pollution at a young age may predispose people to develop Alzheimer's or Parkinson's later in life, according to new research conducted by UM and the National Institute of Pediatrics in Mexico City.

Published in Toxicological Pathology, the research was funded by the National Institutes of Health.

Dr. Lilian Calderón-Garcidueñas, an assistant professor in UM's Center for Structural and Functional Neuroscience, studied the brains of 47 young people who died of causes unrelated to neurological conditions. Thirty-five came from Mexico City – one of the most polluted cities in the world – while the rest were from two Mexican cities with relatively clean air.

Calderón's research group found that brains from the Mexico City area – even one from a 2-year-old child – showed evidence of neural inflammation and features common to those with Alzheimer's or Parkinson's diseases. The average age of those studied was 25.

"This suggests that harmful environmental exposures very young in life can be significant for your brain later when you reach a certain age," she says. "But it may be 50 years before you exhibit symptoms. Alzheimer's and Parkinson's diseases are not sudden. By the time you develop symptoms like cognitive alterations ... you probably have lived with the disease for decades."

Calderón conducted the study in Mexico because people there are less likely to move. In the United States relocation is more common.

Blossoms signal changing climate

Every spring for the past decade, UM forestry Professor Paul Alaback has studied plant cycles on Mount Sentinel. Alaback found that the plants have started to flower earlier — two weeks earlier in some cases.

Alaback describes his research, the science of phenology, as observing "nature's clock." He's concluded that the clock is resetting sooner and ticking faster because of climate change.

Previous U.S. and international studies also have found that plants are flowering three to five days earlier each decade.

"We're getting so much evidence, it's getting harder and harder to argue with the fact that things are changing," Alaback says. "Similar patterns found all over are pretty convincing. Rapid changes have been noticed in climate, ecological and biological responses."

The case of the buttercup is the most poignant. Bitterroot-area researchers have found the blooms in January instead of the normal mid-spring. Alaback found them in February. "That's the earliest I've seen them in 12 years," he says. "Our spring temperatures have risen quite a bit."

But science isn't always as complicated as most think, Alaback says, "It's all about consistency."

So to recruit more researchers, Professor Carol Brewer, associate dean of the UM College of Arts and Sciences, and Alaback joined partners who represent the Chicago Botanical Garden and the University Corporation for Atmospheric Research.

Their venture — Project BudBurst — asks "citizen scientists" across the nation to follow a few phenological steps each spring and submit their findings online.

More than 3,000 people nationwide gathered data for spring 2008, an increase from 2007, Alaback says. Montana's participation has risen too, with citizen scientists in Missoula and Choteau.

But the project won't be able to yield conclusive evidence about nature's clock until a few more growing seasons pass. Decade-long studies like Alaback's Mount Sentinel project are necessary to find constant change over natural variation.

That doesn't mean, however, that phenologists have to wait 10 years to make valuable comparisons, Alaback says. Part of Project BudBurst research will look at how susceptible different U.S. regions are to the same conditions.

BudBurst researchers found that climate patterns are much more complicated in the South, which has less prominent season changes than the rest of the U.S. Researchers there have seen a plant response "more to drought than temperature," Alaback says, "which reflects on the regionalization that will be necessary to studying the effects of climate change.

"Response is going to take different forms wherever you are."

In Montana, plant response may be due more to temperature and how that affects how early snowpack collects and melts, he says. "One of the first places we're going to see the effects of climate change is in the dry valleys of Western Montana [like Missoula]."

But what Project BudBurst needs is time and participation. "The more people who are a part of this, the better job we're going to do. This is a resource that will take some time to develop," Alaback said.

"This is an investment in our future."

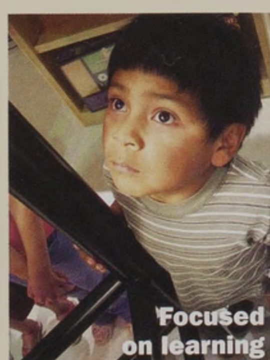
— By Ashley Zuelke

BudBurst 2009 kicks off Feb. 15

To participate go to http://www.windows.ucar.edu/citizen_science/budburst/.

Project Budburst is funded with a grant from the U.S. Bureau of Land Management and the National Fish and Wildlife Foundation.

Kids enjoy science fun center



Focused on learning

UM celebrated the grand opening of its spectrUM Discovery Area last fall. Located in Room 166 of the Skaggs Building addition, this College of Health Professions and Biomedical Sciences center is devoted to inspiring a culture of learning and discovery for kids of all ages.

Holly Truitt, spectrUM co-director, says the center's outreach efforts reached close to 39,000 students during its first year. This included taking fun science activities to schools, fairs, festival and powwows. In addition, 4,700 students visited the center on campus during its first eight months, and a similar number is expected during the latter half of this year. "So usage is really accelerating," Truitt says.

The center is open from 3:30 to 7 p.m. Thursday and from 11 a.m. to 4:30 p.m. Saturday and Sunday. Admission is $3.50; children ages 3 and under are free. Free passes often are available through the YWCA, Missoula Public Library and other means. "We disseminate about 1,000 free passes every month," Truitt says. "We also just had our first birthday party with 227 kids."

The center's current main attraction is a weather exhibition from the San Francisco Exploratorium, which offers an 8-foot tornado, sea of fog and swirling turbulent orb.

SpectrUM is funded by the National Science Foundation's Experimental Program to Stimulate Competitive Research. More information is available at http://www.spectrum.umt.edu.

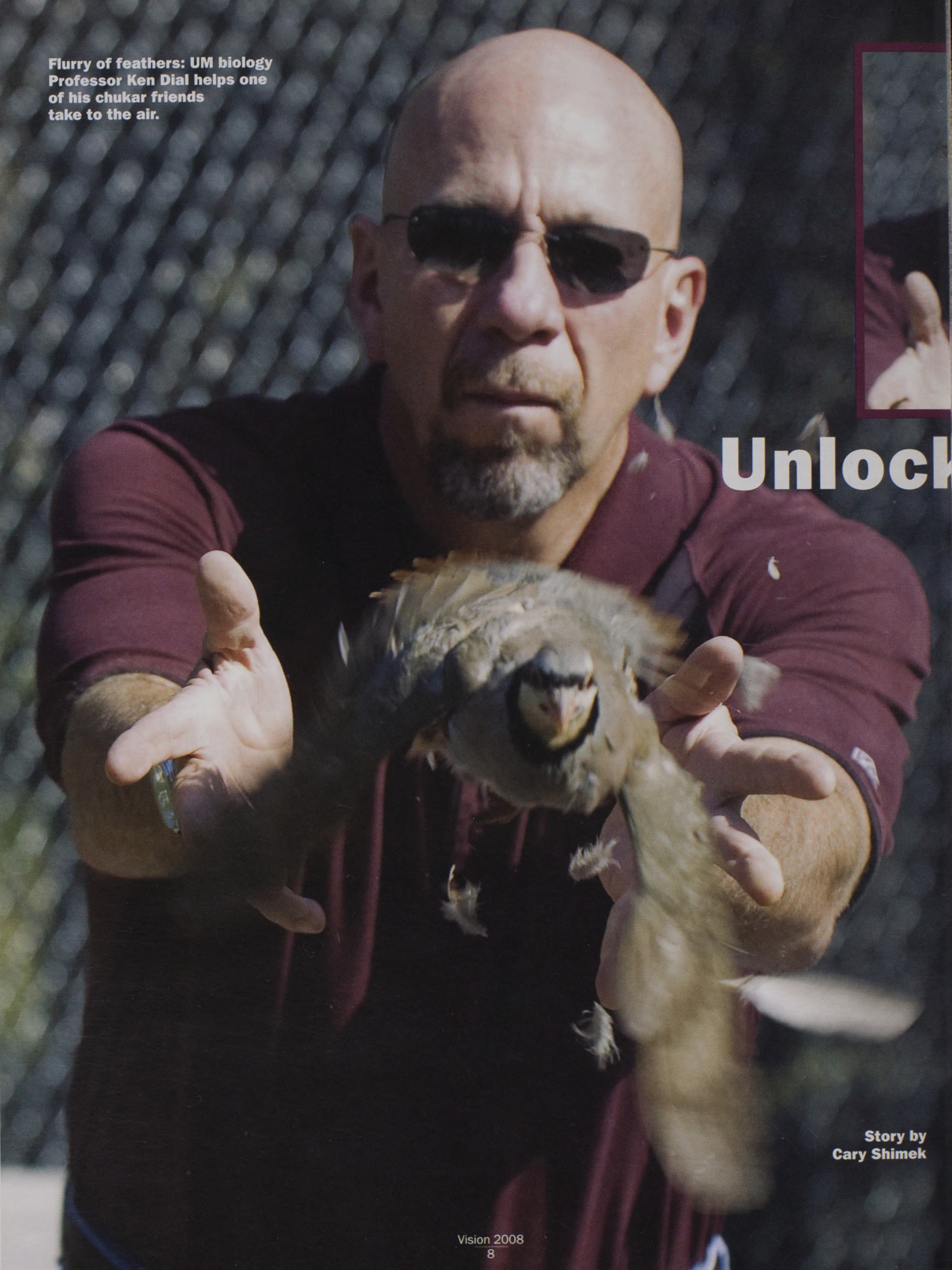
Lab engages American Indian students

UM has established a Native American Research Laboratory dedicated to training Native students in basic sciences. The lab is the first research facility at any university in the nation developed specifically to provide hands-on, cross-disciplinary research training opportunities for Native American undergraduate and graduate students.

The goal of the lab is to provide a cultural "comfort zone" where Native students can learn how to use state-of-the-art instrumentation and modern laboratory techniques to study research questions.

Michael Ceballos, a UM biology research assistant professor, helped develop the laboratory. A former tribal college faculty member, he says the idea is to create learning opportunities for Native science students so they are more competitive in applying for graduate science programs and positions. V

Flurry of feathers: UM biology Professor Ken Dial helps one of his chukar friends take to the air.



Unlock

Story by
Cary Shimek

ing the Secrets of Flight

UM releases new theory of bird evolution

When Ken Dial made one of the sweetest, most surprising discoveries of his career, he swore like a sailor.

It happened like this: The UM researcher and two grad students were working in the University's Flight Laboratory, a high-tech avian research facility at Fort Missoula. Once a U.S. Cavalry stable, the building now sports a modern interior with offices, aviaries, holding cages, a surgical suite, a wind tunnel, electrical gear and lots of different bird species.

Using high-speed cameras, the three documented how birds change the angle of their wings as they gain altitude, glide, descend or run up steep surfaces. Dial, a self-described experimental functional morphologist, has long been interested in how birds are put together – muscles, nerves and bones – and how what goes on inside them affects their behavior. Decades ago he already had made X-ray movies of birds in flight, and now – at 1,000 frames per second – he was trying to understand, down to the most minute detail, the mechanics of how they take to the air.

One of his grad students, Paolo Segre, was putting the birds through their paces and recording the results. He somewhat sheepishly reported to Dial that the avians – in this case chukar partridges – weren't really changing their wing angle as they flew higher, descended or flapped their wings to help them run up steep surfaces.

"You're full of soot," Dial responded. (Actually he didn't quite say that. Anyone who has worked in the lab with Dial long enough knows his language gets a bit more salty.) "Go back and do it again. This can't be right. The physics doesn't make sense."

But when the chastened Segre tried again, this time with the help of the other student, Brandon Jackson, results were similar. Soon Dial was involved, and all scratched their heads as they watched videos of the birds perform in ultra-slow motion. Something wasn't right ...

"Then all three of us went, 'Holy Shoot!* They really aren't changing their wing angle!'" Dial says. "Then we stopped to think about how that could be. And we realized we had to rethink what we were imagining the birds were doing."

What the birds were doing was keeping their wing strokes confined to a narrow range of less than 20 degrees for a wide range of behaviors. This similar wing flap directs aerodynamic forces about 40 degrees above the Earth's surface, permitting a 180-degree range in the direction of travel.

Dial and his crew – like the rest of the scientific community – had always assumed that birds were doing something extremely complex with their wing angles as they flew. What they discovered was something simpler and basic hidden in behaviors everyone has seen countless times. It was a fundamental wing angle.

"I had it wrong," Dial says. "It turns out they weren't changing hardly anything at all." He holds out his hand flat, angled slightly above the horizon. "The wing is doing this the whole time, and the body is slinging around it like a gymnast on the rings. The wings always produce a force that is similarly orientated against gravity. The body slings around so much that it looks like the wings change position. But they don't."

Dial says bird wings produce lift and thrust forces at the constant angle. If they encounter a rock, cliff or any other textured substrate within the path of the forces of the wing stroke, birds use this

* Once again, edited for language.

force to hold themselves against the substrate while the legs do the work to lift the animal up the obstacle. If there is no obstacle, the same wing stroke functions for flight.

The findings became a big deal when they were published last January in Nature, a leading science journal. Dial and his two grad students co-wrote the piece, which spawned articles worldwide, from National Geographic News to the Tehran Times.

Bird flight — an almost magical aerial dance to the human eye — had just become a lot simpler. And Dial thought the basic nature and utility of the finding might help explain how birds evolved to take to the skies in the first place.


Wingman: An expert on bird flight, Ken Dial also is an accomplished jet pilot with multiple certifications.

The son of an aeronautical engineer, Dial grew up blocks from the runways of Los Angeles International Airport. He became fascinated by airplanes and the idea of flight, but his youthful experiences in the outdoors — especially as a Boy Scout — gave him a stronger attraction to the biological world.

"I never lost my little-kid attitude of 'Daddy, how does the world work? What's under this rock? How did this thing come to be?'" Dial says. "I became greatly interested in vertebrate design and evolution — how things with backbones are put together. Everything from a fish to a bat to a whale is related, and how could that be? How could they move and have similar muscles and bones and some be the size of an eraser and some the size of a building? That is a terribly exciting thing to think about."

Dial was a mammal guy in college, and his doctorate was in mammalian ecology, life history biology and evolution. In the '80s he came to believe his university education was imbalanced — that he was trained primarily in field biology and statistics and needed to know more about form, function, anatomy and physiology. This resulted in a postdoctoral fellowship at Harvard University and time spent at a medical school and a museum of comparative zoology.

"Over those three years I got my head screwed on about the internal components of vertebrates," he says. "And I came to realize there are tons of work on bird behavior and bird ecology, relatively speaking, but next to nothing on how animals move, how they are put together and what goes on inside to allow them to behave."

While completing his education, Dial pursued another passion: aviation. He earned his pilot's license in 1981. He also holds instrument, commercial and multi-engine licenses, is rated for turboprop and jets, and can fly as an airline transport pilot. Over the years he has amassed more than 2,000 flight hours.

Why would a college professor rise to that level of flying proficiency?

"I have no idea," Dial says. "I was training when I was doing my doctorate and taking my post-doc in Boston. Don't bring this up around my wife, Karen (of 34 years); she watched me go through all these gyrations training as both a pilot and biologist. When I find something I'm interested in, I become insatiable about things."

Dial came to UM in 1988 and soon also took flight as a world-class ornithologist. He's had 24 years of consecutive National Science Foundation funding, and his research program has garnered millions in grants. He has written more than 60 scientific papers and has been published six times in the prestigious journals Nature and Science.

He lives in Montana because "A lot of my questions come from just standing in a river fly-fishing. It's not uncommon for me to come running to the lab to do an experiment because I simply had time to stop and think."

When he wasn't studying birds, flying or fly-fishing, Dial found time to host 26 episodes of the Discovery Channel's "All Bird TV" during its two-season run in the late '90s. With rough language firmly in check (on camera anyway), he introduced viewers to interesting feathered friends from Alaska to Costa Rica.

All this probably explains why the scientist has the word "FLIGHT" emblazoned on his car license plate.

Dial has made a career out of slowing down time to reveal what's hidden right before our eyes.

Case in point: In 2003 he used high-speed cameras to study how chukar partridges go from chicks scurrying around on the ground to full-fledged flight. How do they do it? What are the mechanics of their development? What good is a half-grown wing that birds can't fly with yet?

The vast majority of the world's birds are songbirds. Dial says these are highly evolved, "derived" fliers because they employ sophisticated parental care. They locate a habitat and build a complex nest. The parents tag team taking care of the chicks. The chicks sit in the nest for two to six weeks, depending on the species, and grow to adult size. Then they eventually stretch their wings and fly away.

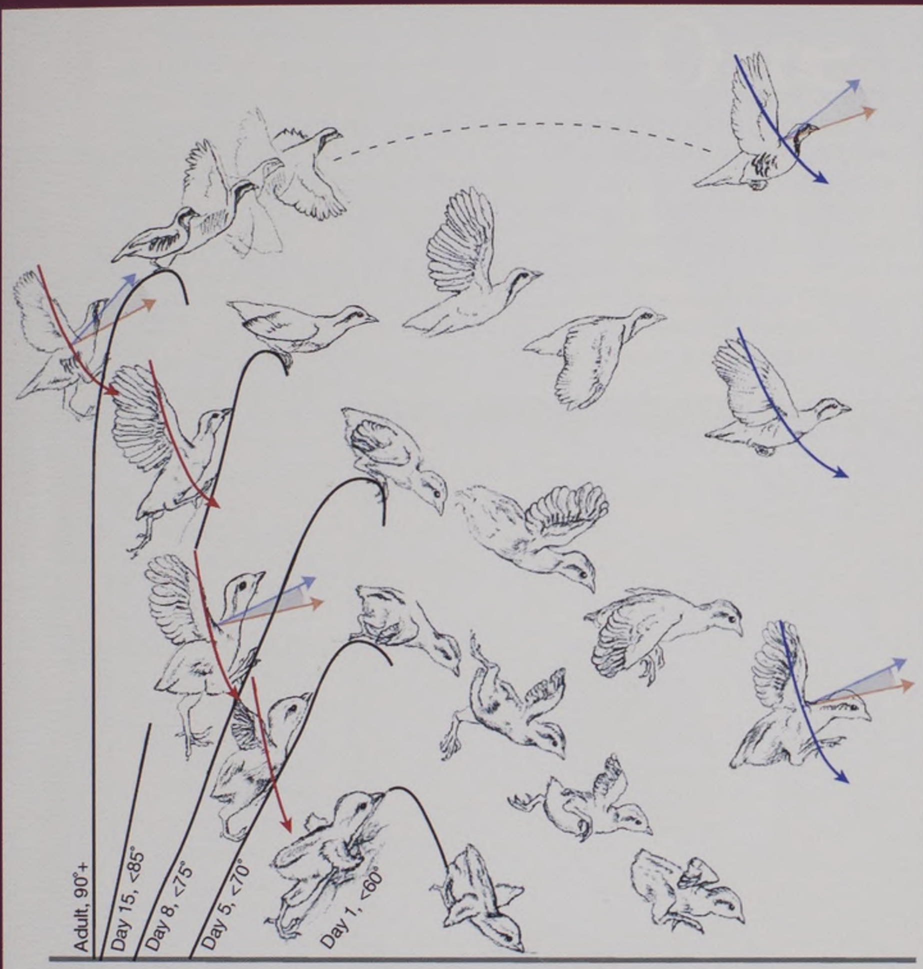
Not so with chukars and similar ground dwellers such as quail, turkeys and chickens. They can walk the day they hatch to help avoid predators, but they develop the ability to fly incrementally. They have to fend for themselves. Dial wanted to videotape the process these more primitive birds go through.

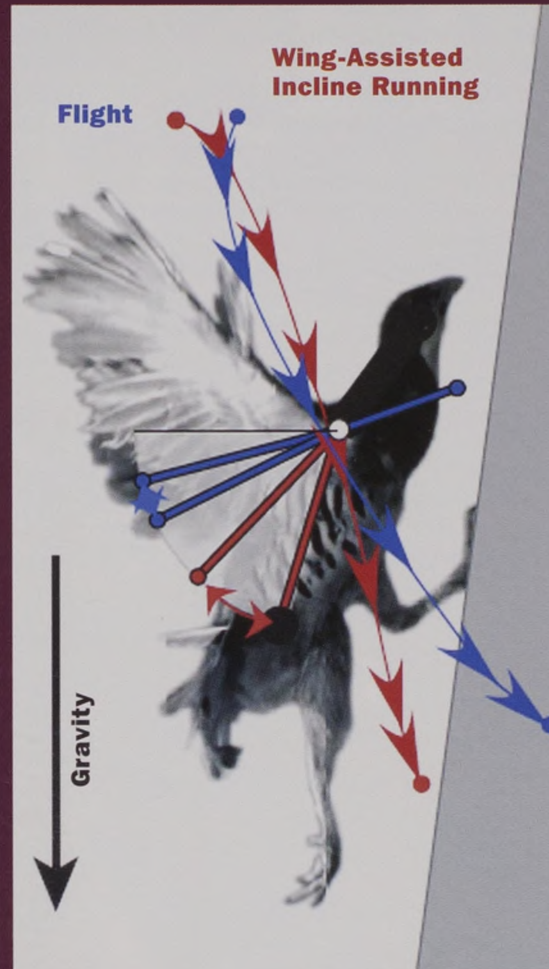
An experiment was designed where chukar chicks were placed on an elevated perch such as bales of hay. One was removed from its siblings and videotaped as it scrambled and flapped back to the group on a daily basis. In another test, the birds were placed on a table, and one was separated on another table. On day one, the tables were 2 inches apart. In a week they were 3 yards. By the end the bird was flying 100 yards between tables. The point of these experiments was to document how the creatures developed flying performance both vertically and horizontally, from hatchling to adult.

Dial was away at Harvard doing research when a breakthrough came. He had employed two high school students — his son, Terry, and family friend Ross Randall — to exercise and videotape the birds. One day when Dial called to ask how the birds were doing, his son said, "Lousy! They aren't flying anymore. They are cheating!"

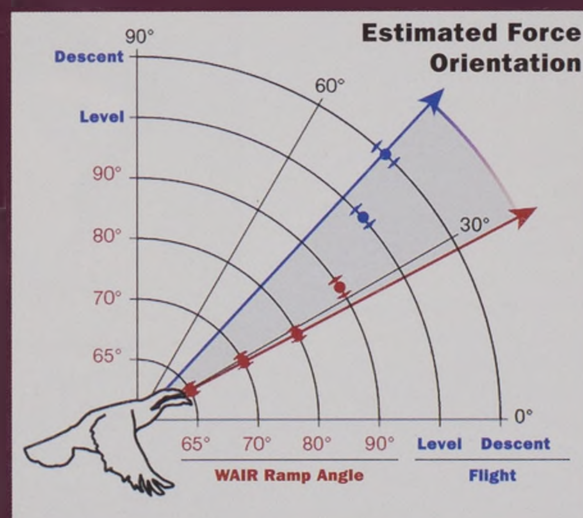
Cheating?

Terry informed his dad that during the elevated-perch experiment, the flapping birds appeared to be running straight up instead of flying. They were cheating by





(Above) Partridge power: This graph shows the phases and time it takes chukars to go from hatchlings to adulthood by using wing-assisted incline running and controlled flapping descent. (Upper right) An illustration of the forces and wing angles chukars use to overcome gravity. (Right) A graph showing the angle of forces used by chukars to run up steep surfaces and take to the air.



using their clawed feet in combination with their half-grown wings.

It was an epiphany. Slow-motion cameras slowed down reality enough to reveal the birds used their wings like the spoiler on a race car to stick their feet to the surface they were ascending. With their developing wings, the birds could run up nearly vertical surfaces such as hay bales, trees, rocks and cliffs. (Some species can run up inverted surfaces that are more than 90 degrees.) People have seen chickens doing it since the dawn of history, but everyone assumed they were flying. The videos revealed that, no, they were flap-running.

Dial dubbed the behavior WAIR — wing-assisted incline running. He says WAIR gives ground-dwelling avians a survival advantage. His lab has tested it in at least 20 bird species, and even duck-like ones use WAIR. (Notable exceptions are large flightless birds such as ostriches and emus. Other than for heat regulation and mating rituals, the use of their wings remains an enigma.)

The WAIR findings spawned an article in Science that garnered worldwide attention. It popped the eyes of many in the ornithological world.

As for those two young high school research assistants, they got to be co-authors of a major scientific article in the journal BioScience. And both stuck with biology when they went to college.

"Ross is earning his Ph.D. in molecular biology," Dial says. "And my son is doing his doctorate in experimental functional morphology — kind of the area I'm in. Both are going to be fabulous scientists."

What use is half a wing?

When Charles Darwin unleashed his revolutionary theory of evolution in the mid-1800s, one of the first questions doubters nailed him with went something like this: You have the four limbs of a reptile and then a beautiful flying bird. What are the intermediary steps? Darwin, what use is half a wing?

There wasn't much the esteemed naturalist could say back then. And during the next 150 years, scientists largely divided themselves into two bickering theoretical camps regarding the evolution of flight.

The arborealists, who are generally ornithologists, think bird ancestors first took wing by climbing trees or cliffs and then gliding down from them. Certain lizards and flying squirrels exhibit this behavior. In the opposing camp are the cursorialists — usually paleontologists who note the similarities between dinosaur and bird fossils — who claim early birds ran along the ground, beat their feathered forelimbs and eventually took off.

Dial says a lot of "silver-backed biologists" have spent their careers writing untold volumes of work defending the aboreal and cursorial positions. He says they can be rigidly dogmatic in their beliefs.

Now Dial and his crew have discovered in the laboratory that half a wing indeed can be useful. He has entered the evolution-of-flight fray by offering a third rival idea – the ontogenetic transitional wing hypothesis, or OTWH. (Ontogenetic means the development of something.) This theory suggests that birds evolved incrementally by using their half-developed wings to run up steep surfaces (WAIR) and gained a survival advantage. Then they flapped their proto-wings to return to the ground safely. And, by the way, it's no great leap to cross between these behaviors because they are linked by a fundamental, constant wing angle.

"We think our theory is a convergence of thought that's a more complex marriage of the arboreal or cursorial camps," Dial says. "We have taken the beautiful sage elements from each one, and I feel we integrated them perfectly to say you never needed to go strictly from the ground up or tree down."

So does Dial get hate mail from silver-backed biologists for his "heretical" new theory?

"To be honest with you, I'm pleasantly surprised at how well received this hypothesis has been," Dial says. "Frankly, it's starting to take over the textbooks."

The reason for that, he says, is that OTWH is based on more than belief. He has demonstrated scientifically how half-developed wings can be useful. He speaks of putting baby chukars in a chamber filled with a fine mist of olive oil. "It looks like a smoky bar, but it smells like an Italian restaurant," Dial says. As the bird flap-runs up a steep surface, a laser is shot against the wings while cameras record and computers measure the mini-tornadoes of oil particles spawned by the aerodynamic forces of the moving appendages. This produces images where tiny swirls of arrows reveal the speed and direction of these forces. Dial says the whole process is called digital particle imagery velosometry.

"The eons-long evolution of flight is revealed to us in the development of baby birds," Dial says. "Our thesis came out from the demonstration of what living animals actually do. And now we have fossils that we never imagined being discovered in China, South America and Africa that look exactly like we expected – dinosaurs with feathers; dinosaurs with half a wing."

He says the evolution of flight in birds was a messy affair that likely happened during a span covering tens of millions of years. The first bird-like fliers began appearing 150 million years ago.

But just imagine this: There was a time before flying birds, a time when reptilian things on two legs screeched and flapped their suddenly useful forelimbs to escape predation, reach safer habitats and rise above the competition to survive and reproduce. According to Dial's theory, there was a period before true bird flight when, for proto-birds at least, WAIR and its related behaviors were the only show in town.

For a time, half a wing was good enough, and it became the stepping stone nature needed to populate the skies.

By Peter Schouten, from "Feathered Dinosaurs — The Origin of Birds" by John Long and Peter Schouten

In the beginning: This artist's rendition shows a Caudipteryx zoui, a proto-bird that lived about 127 million years ago. It had well-developed branching feathers but could not fly. Its fossil remains were discovered in 1998 in Liaoning Province, China.

Many people are interested in Dial's work for its possible applications beyond biology. His dogged pursuit to understand every detail of flight in nature may someday contribute to the worlds of aerodynamics and aeronautics.

"We talk about getting microstructures onto aircraft wings," he says. "You could have the full structure of the wing, and on top of it you could have these very light tabs like feathers that change the airflow in a very sophisticated, computerized way. You could get greater lift, much greater endurance, more control and probably a lighter structure."

His research also could lead to aircraft wings that change shape to accommodate slow and fast flight, and do it all with one structure. Dial says an airplane is two structures – an engine and a wing – while a helicopter is more like a bird, because the spinning rotor is both the wing and propeller.

"Birds and helicopters have a lot in common in the sense that their wing and propeller give them both lift and thrust," Dial says. "So there have been discussions of how to change the shape of the propeller dynamically."

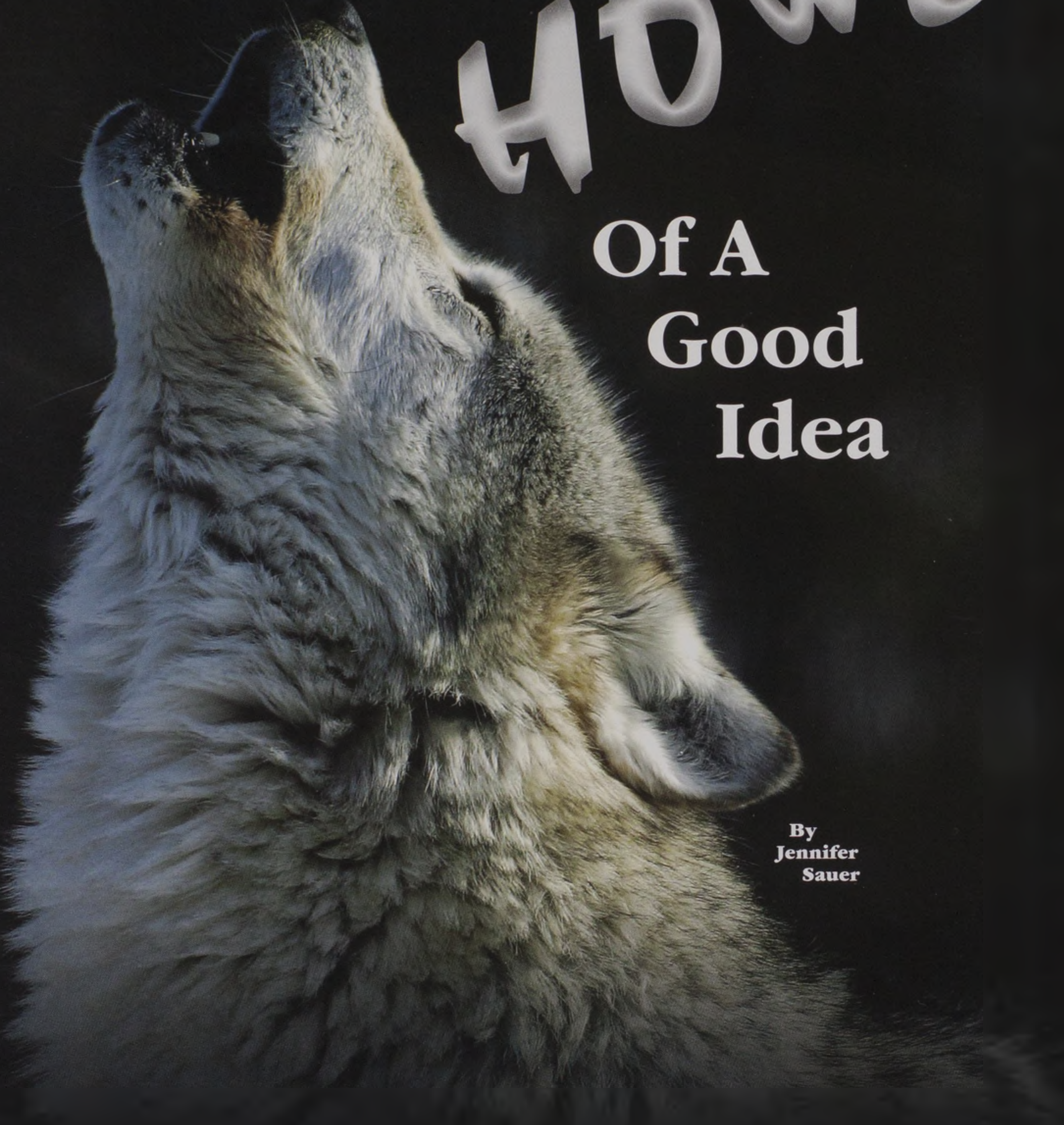
Dial says the government also has approached him about the possible defense applications of his research, such as creating spy robots that can climb walls or fly. But that's a path he's chosen not to tread.

"Perhaps selfishly, I'm still too much like that juvenile little boy asking, 'How does the world work?'" he says. "I'm still too engaged in trying to figure out how all this spectacular tapestry of life fits together." V

For more information, e-mail kdial@mso.umt.edu.

One HOWL Of A Good Idea

By Jennifer Sauer



UM scientists create innovative listening device to track wolves

Tracking the elusive wolves of Idaho is a costly and exhaustive endeavor.

The shadowy animals inhabit some of Idaho's — and the country's — most rugged and isolated terrain. The average pack of seven animals ranges across about 300 square miles, and each pack member can easily crisscross that distance in a day or two.

These factors — along with their aversion to humans — make keeping an accurate count of the wolf population challenging at best.

Now UM researchers are putting innovative new monitoring methods into practice to better estimate wolf populations. Their developments come as Idaho and Montana prepare to take the reins of wolf management from the federal government. Although the delisting of wolves remains tied up in court, states will eventually shoulder the responsibility of managing the animals.

"We are about to make this transition from an endangered species to a game animal overnight," says Mike Mitchell, unit leader of UM's Montana Cooperative Wildlife Research Unit.

The work of unit researchers is important right now because the delisting of wolves and the accompanying shift from federal to state management also means the end of federal funds to monitor the animals.

States with wolf populations such as Idaho and Montana are required to monitor and maintain a minimum number of breeding pairs for five years after delisting. That means the cash-strapped states will be looking for the best and most efficient data collection methods.

Those involved in wolf research also recognize that ensuring the survival of the animals requires better monitoring methods. With that in mind, Mitchell and his team of researchers set out to develop the most cost-effective and reliable monitoring techniques, which will provide state agencies with at least the same level of information that federal agencies work with.

Among the promising new methods is the Howlbox, an invention that is the brainchild of Dave Ausband, research associate at the Montana Cooperative Wildlife Research Unit.

The Howlbox takes the passive listening device — a tool often used to study frogs, bats, whales, elephants and others creatures — one step further. Researchers know that wolves, especially young pups, will often respond to a howl they hear in the wild. Ausband came up with the idea to create a computerized device that emits a howl, then switches to "record mode" to capture any response.

"It's really an unprecedented research and management tool," Mitchell says.

Ausband dreamt up the Howlbox in 2007 and quickly put then-undergraduate researcher Teresa Loya to work creating a prototype. She created the first model in about four months.

"I have the luxury of having some computer programmers in my family," Loya says. "My family members have played a huge role in developing the Howlbox."

The device consists of a computer, speakers, microphone, battery pack and case. Once mounted to a tree in the research area, the computer turns on twice a day — at dawn and dusk when wolves are most likely to howl. The computer broadcasts a "lonesome howl," a real wolf howl that Loya and Ausband obtained permission to use from renowned researcher Fred Harrington of Nova Scotia. Then the computer switches to "listen" mode and records for two minutes. It repeats the broadcast-and-record sequence twice more, and then turns off.

Ausband wanted a device that could provide researchers with data about wolves living in remote areas that must otherwise be obtained using costly and labor-intensive methods such as tracking, DNA collection and genetic testing. By letting a computer collect data, the Howlbox could provide reliable information without the cost of sending crews into the wild for weeks at a time.

"We wanted to have it broadcast and record while I'm at home playing with my kid," Ausband says.

With the prototype in hand in January 2008, Ausband and Loya skied two miles into the Bitterroot Mountains and mounted the first Howlbox in an area where a pair of collared wolves was known to frequent.

"We had no idea if it was going to work," Ausband says.

Two days later they retrieved their invention and began the drive home to Missoula. Ausband was behind the wheel as Loya connected the device to her laptop. Within moments, the Howlbox played back its first recording of a wolf howl.

"I almost drove off the road," Ausband says.

"That very first howl sent out, the very first recording, we had a duo," Loya says. "It was unexpected. It was phenomenal."

During the first 48 hours the Howlbox was in place, it recorded 14 responses from the nearby pair.

Last summer, Ausband and Loya put four Howlboxes to work in the wilds of Idaho and labored to resolve some of the kinks they found along the way. Trial and error taught them that the Howlbox microphone will pick up the closest sound: the rushing river, the rustling of aspen leaves or, in one case, National Public Radio news

Photo by Dave Ausband

The quarry: Wolf pups, like this one near its den along Idaho's Payette River, will often respond to howls — real or recorded.

Left photo by Jason Husseman. Others by Dave Ausband.

(Left) UM Research Associate Dave Ausband and a sedated wolf near Salmon, Idaho. (Middle) Undergraduate student Teresa Loya sets up the Howlbox in the Nine Mile Valley near Missoula. (Right) A Howlbox deployed in a tree.

emitted from a nearby radio tower.

"There has been a lot of frustration, of course," Loya says, "but that's a part of it."

Soon, the team hopes to have a user-friendly device so others can gather reliable data in the field. The goal is to keep the cost of the Howlbox at around $1,500 so that managing agencies can afford it.

But the Howlbox is just one of the new methods that researchers at the Montana Cooperative Wildlife Research Unit are using. Through a new analytical framework called Patch Occupancy Modeling, researchers are combining various data streams to estimate wolf populations in a more efficient and precise manner than ever before.

Using information gleaned from the new tools such as the Howlbox and more traditional methods such as hunter surveys, public sightings, scat collection and radio collaring, researchers are creating what Ausband calls a "statistical stew pot" of information to estimate statewide wolf populations more accurately.

"If you use Patch Occupancy Modeling, you can take apples to oranges and turn them all into oranges," Mitchell says.

Mitchell and Ausband began their work by estimating Idaho's pack numbers. But those involved with wolf management ultimately want to know how many individual wolves roam within Idaho's borders. So Mitchell and Ausband set their sights on gathering more detailed information on wolves inhabiting remote, rugged areas that are rarely visited by humans.

Another one of Ausband's successful ideas was to map wolf "rendezvous sites," where packs stash their pups for the summer as the adults come and go. Once researchers locate an active rendezvous site, they can glean a minefield of data by using all the research tools available.

Ausband used Geographic Information Systems to detect areas that looked like wet meadows, which wolves prefer for rendezvous sites, across Idaho's remote backcountry. In 2007 he sent workers out around those wet meadows to conduct population surveys. Other data told Ausband and Mitchell that there were nine litters in those areas. Using the GIS data, crews found seven of those nine litters.

"That's an exercise in finding needles in a haystack," Mitchell says.

Crews working during the summer of 2008 collected 200 scat samples from a rendezvous site in one week. That far exceeds the amount of data collected by simply driving forest roads looking for scat, a method used in the past.

"You could drive around for six months and not find 200 samples," Ausband says.

The foundation for the development of the Patch Occupancy Model was laid years ago by the Nez Perce Tribe in Idaho, Mitchell says. The tribe took a lead role in reintroducing wolves to Idaho in the mid-1990s, and they were visionary in anticipating the delisting of wolves a decade later. They have funded the bulk of the work, along with other contributing agencies such as Idaho Fish and Game; Montana Fish, Wildlife and Parks; the U.S. Fish and Wildlife Service; and the U.S. Geological Survey.

The original grant that funds Mitchell and Ausband's research runs out in November, but both remain optimistic that additional funding will carry their projects forward.

"Graduate students are going to be doing this for years to come," Mitchell says.

For those who work with wolves, observing a mammal that had virtually disappeared in the Western U.S. two decades ago rebound to become a thriving species that will soon be managed as a game animal is nothing short of amazing. According to Mitchell and Ausband, that's what makes their work so meaningful.

"This is not a strictly academic exercise," Mitchell says. "From a researcher's point of view, this is an incredible opportunity."

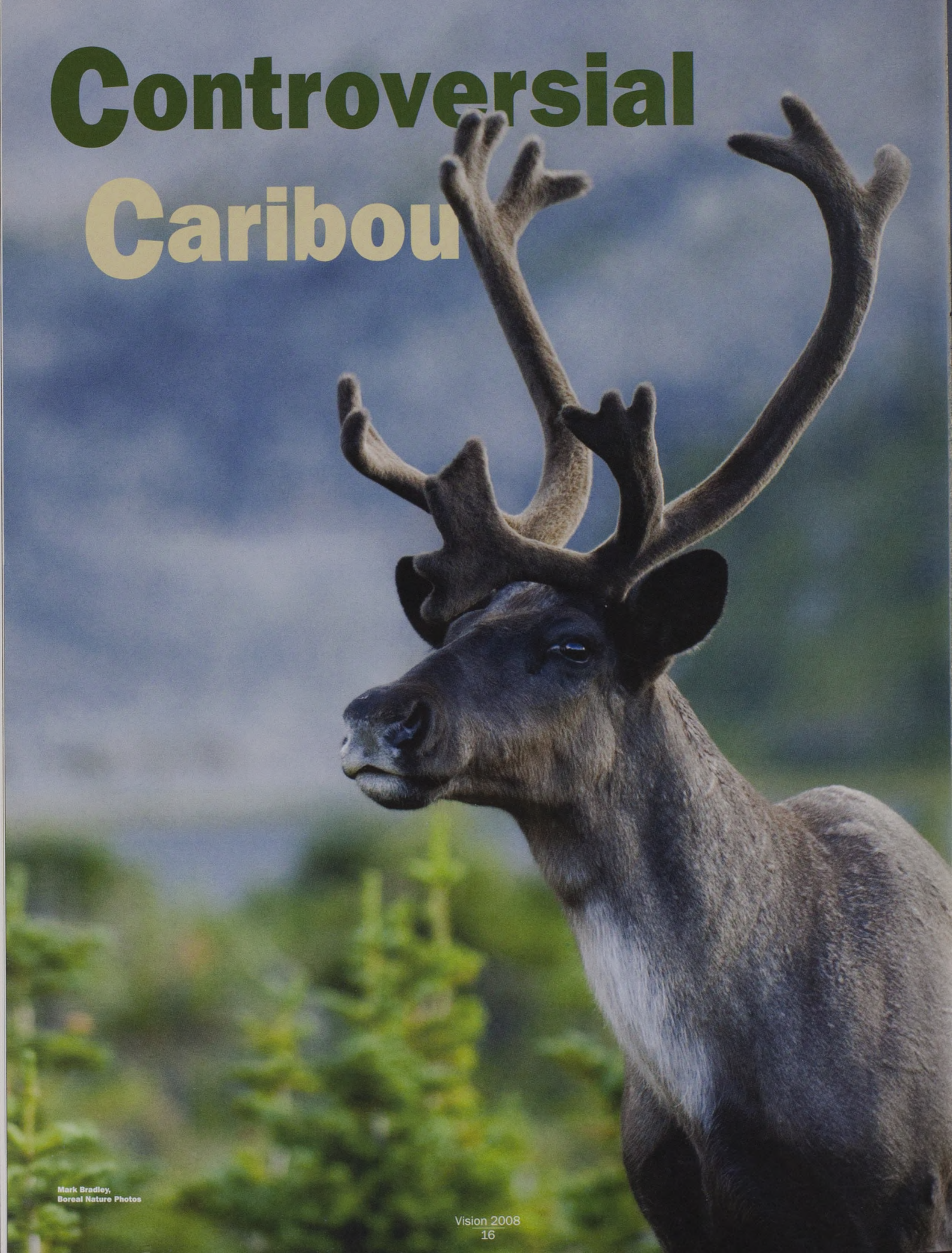
In the end, Mitchell says, Montana Cooperative Wildlife Research Unit researchers will say, "We helped make a real contribution to help wolves stick around."

For Ausband, it was a moment in the field that really drove home the meaning of his research. Working in the Idaho backcountry, his crew trapped a wolf and began working to tag it as Ausband's young son toddled along behind them, seemingly unaware of the significance of encountering a wild wolf in its natural habitat.

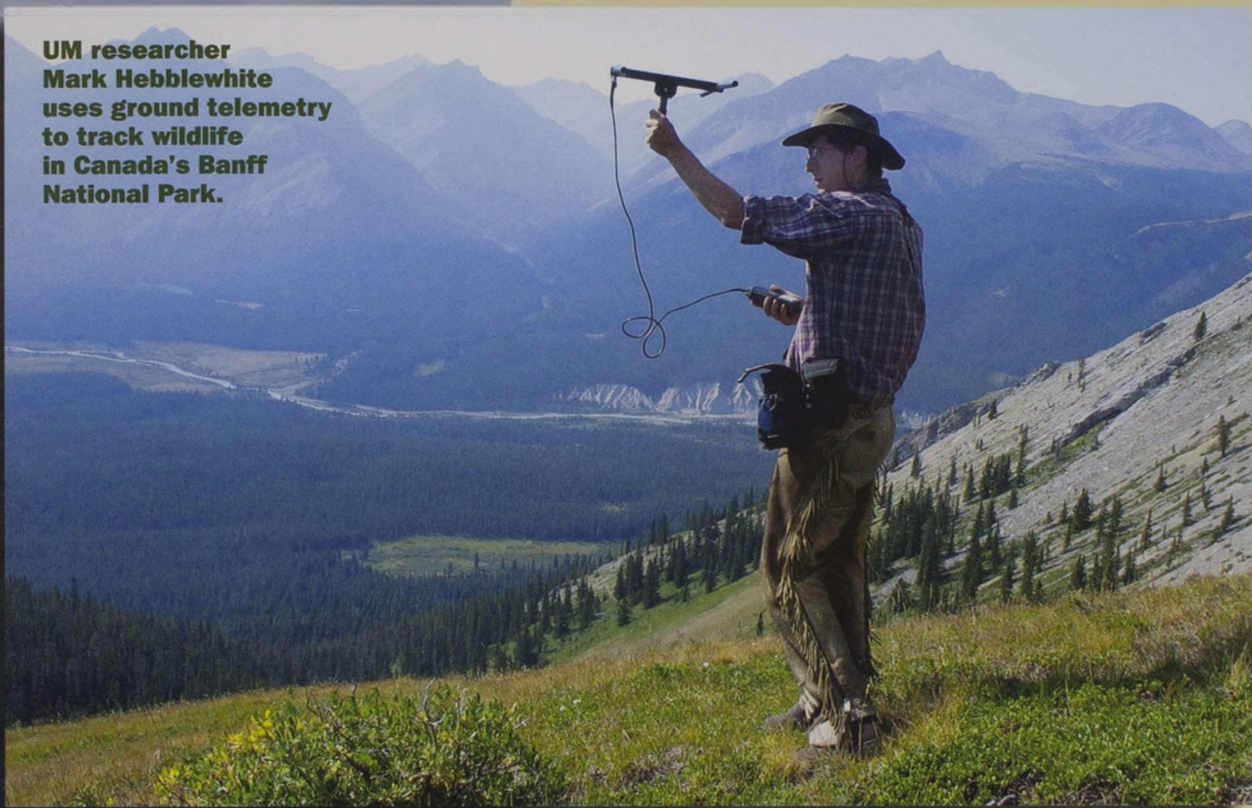
"I was 22 before I saw my first wolf," Ausband says. "He wasn't even 22 months. He has no idea that there were no wolves in Idaho 10 to 12 years ago. It kind of blew me away." V

For more information, e-mail david.ausband@mso.umt.edu or mike.mitchell@umontana.edu.

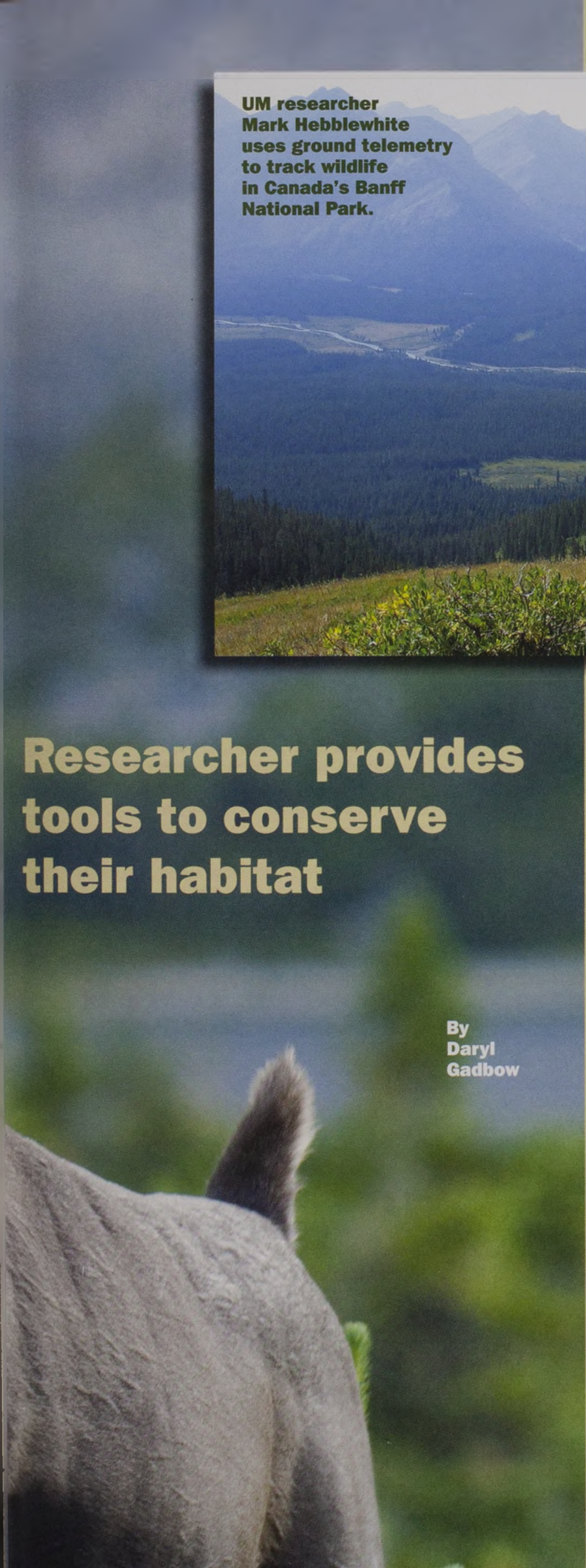
Controversial Caribou



Mark Bradley,
Boreal Nature Photos



UM researcher Mark Hebblewhite uses ground telemetry to track wildlife in Canada's Banff National Park.



Researcher provides tools to conserve their habitat

By Daryl Gadbow

The northern spotted owl has long been a creature of controversy in the United States — relished by conservationists and reviled by conservatives.

Now UM researcher Mark Hebblewhite says the woodland caribou may be filling a similar niche in Canada.

A wildlife researcher and assistant professor at the UM College of Forestry and Conservation, Hebblewhite has focused his studies for the past 15 years on wild ungulate herbivores and their relationship with their primary natural predators — wolves — across Canada, the United States, Eastern Europe and Mongolia.

"Caribou are a weird ungulate, a strange ungulate," says Hebblewhite.

Other ungulates, such as elk, deer and moose, he explains, relish "young" habitat — the type that features rapid growth of new shrubs, forbs, grasses and other forage that typically thrive in open country. It's the sort of habitat that might be produced by natural causes such as fire or by the large-scale timber-harvesting practices of man.

Woodland caribou, on the other hand, seek out "old" habitat, Hebblewhite says.

"They eat lichens to survive the winter," he says. "And lichens depend on old forests. Woodland caribou are like the biggest, ugliest spotted owl you can think of. They need huge chunks of old, boreal forests, over a huge area."

Caribou bulls forage for alpine forbs and lichens in the high country of Canada's Jasper National Park.

Mark Bradley, Boreal Nature Photos

Caribou require large areas of old-growth forest as winter range, adds Hebblewhite, because when portions of forest are destroyed periodically by fire, they can easily move into a similar sanctuary nearby.

Recent timber-harvest practices in Canada and the U.S. have wiped out vast expanses of forest across the woodland caribou's range, Hebblewhite says.

"What we've done is taken these big chunks of winter range that moose and wolves don't come into, and converted them to young forests that wolves, elk and moose love," he says.

Caribou evolved a strategy to avoid wolves in boreal forests, and now, Hebblewhite says, they're "bumping into" the predators more and more frequently. The result is an alarming decline in caribou populations.

"They're endangered in the U.S. (found only in northern Idaho and Washington) and threatened in Canada," Hebblewhite says. "A third to half of Canadian populations are declining because of human causes. Wolves are the proximate cause of caribou decline. But the ultimate cause is this land change."

Conservation of woodland caribou — which are distinct from the barren-ground caribou that inhabit the tundra of northern Canada and Alaska — has become Hebblewhite's main research project.

He is the lead investigator of a massive, four-year, interagency study of the imperiled animals in British Columbia and Alberta, directed by the Canadian government and involving UM and the universities of Calgary and Alberta.

Hebblewhite's analogy of the northern spotted owl is apt.

When they were listed in 1990, spotted owls became one of the most famous symbols of the 1973 Endangered Species Act in the United States. Mandated protection of habitat was deemed critical for the species' survival.

The equivalent Canadian law — the Species At Risk Act — is only five years old. Woodland caribou are now classified as threatened under SARA.

"One of the first animals to come on the list (as endangered) is going to be woodland caribou," says Hebblewhite, because of drastic population declines as a result of human activities — oil and gas development, widespread clear-cut logging practices, urban development and increased recreational intrusions.

Of the 11 populations of caribou that Hebblewhite and his team of UM graduate students study, he says, "three populations could go any day. One population is down from 300 animals to 80 in just the last few years.

"The situation (in Canada) is much like the grizzly bear in the U.S. 20 years ago," he says. "They're trying to turn the population around."

Hebblewhite is a member of a science advisory group appointed by Canada's federal government to help woodland caribou recover. The group is charged with identifying key caribou habitat, which under SARA must be protected, or — as under the ESA — mitigated if that habitat is damaged or destroyed.

"What this whole project is trying to do," says Hebblewhite, "is to help caribou recover by providing a strategy across a broad landscape scale. We've already got tons of development. How do we spatially structure that development to best conserve caribou?"

His research is designed to create the tools for government and industry to accomplish that goal. He believes that integration of science and policy is necessary to save the caribou.

Hebblewhite's research combines old-fashioned fieldwork with the latest advancements in technology.

UM grad students trained and supervised by Hebblewhite perform much of the on-the-ground operations, spending weeks at a time in the backcountry, evaluating habitat, and observing and trapping caribou, as well as wolves. The animals are fitted with collars equipped with radio transmitters that allow the biologists to track their movements through aerial telemetry in planes and helicopters.

The collars also feature Global Positioning System units that provide the exact location of each animal. If the GPS unit suddenly stops functioning or shows no sign of movement, it usually indicates the animal has died. The biologists can then investigate and determine the cause of the fatality.

Wildlife data collected in the field is incorporated with information gathered from satellite images that reveal ongoing changes in caribou habitat caused by various human developments — roads, seismic oil and gas test lines, pipelines and forestry. Displayed graphically on computer-generated maps, the overlaid data creates a valuable new tool known as Geographic Information Systems.

"GIS allows natural resource managers and scientists to understand the real-time consequences of habitat loss and fragmentation to natural systems by keeping track of the spatial information about human development and its impacts on wildlife," Hebblewhite explains. "By combining remote sensing from satellites with GPS collar data in a GIS, we can study the impacts of humans on wildlife and make firm recommendations to natural resource managers and the public. It also allows us to develop specific tools that managers can use to gauge the impact of proposed future developments on wildlife."

Scientists' understanding of the woodland caribou's specialized habitat requirements is coming too late to save all the separate populations across their historic regional range, Hebblewhite says.

"Many herds are now in national

parks," he says. "And those populations are doing OK. What we're looking at is this big regional scale, trying to provide guidelines for management and industry to determine where can we save these herds. If we try to save them all, we're going to fail."

Hebblewhite proposes a threefold strategy to protect woodland caribou.

The first priority is to try to determine which herds are located in relatively pristine habitat that could be protected by creation of new parks or other conservation approaches.

The second strategy, says Hebblewhite, is "to determine what herds we have to write off because there's no way to recover them. Once they've passed a certain threshold of development on a particular piece of landscape, we've found we can't keep caribou there anymore."

And his third recommendation — which he maintains is the one of most interest to industry — is to determine which herds, with careful management, can be preserved while allowing development to proceed.

"That," says Hebblewhite, "is the model of sustainable development."

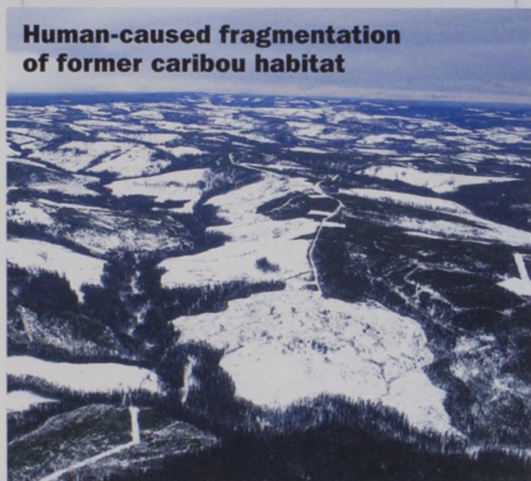
For example, if a company wants to put in a pipeline or timber clear-cut, it must carefully weigh the location to avoid prime caribou habitat.

"They need to know the number of caribou affected," he says. "It comes down to money. So we're building GIS tools to help them determine the effects and costs and benefits to animals."

The value of those tools to companies, according to Hebblewhite, is demonstrated by the primary funding for his caribou research, which is being provided by the Canadian Association of Petroleum Producers, Shell Canada and Weyerhaeuser Canada, as well as Parks Canada.

A native of Canada, Hebblewhite received a master's degree at UM and then came to teach at the University in 2006 after earning his doctorate at the University of Calgary.

Besides the woodland caribou project, Hebblewhite's other current research



Human-caused fragmentation of former caribou habitat

includes studies of the response of Sierra Nevada bighorn sheep to fire on winter ranges and managing urban elk in seven western U.S. states, including Montana.

He says ungulates and their predators are particularly appropriate subjects of scientific scrutiny.

"Large charismatic megafauna like wolves, elk and caribou are important for three main reasons," he says. "One, is that species like wolves are important ecosystem drivers and perhaps keystone species that help shape entire ecosystems. My research has demonstrated that wolves help restore aspen forests by reducing elk densities.

"Two, they are umbrella species, whose protection requires large areas of protected habitat under which many other species are thought to also be protected.

"And three, they serve as flagship species that attract people's attention, money and conservation efforts to help protect other less charismatic species that might be as attractive for conservation reasons."

All his current research projects reflect a trend toward examination of wildlife issues across an increasingly broader scale of geographic landscapes, or, as Hebblewhite describes it, "the bigger picture."

"It's very important," he says, "that wildlife biologists think about things like climate change, the scale of urban development that's occurring across the West and the energy development that's racing across huge regions.

"It's a difficult problem for wildlife conservationists to say that the results of one study apply across a wide scale or affect different populations. To be effective, wildlife biologists have to look at big issues, like the timber changes around the world. Ungulates are concerned with two things: finding food and avoiding predators. All these changes affect that balance. All of our projects are trying to work at that big landscape scale, even on a continental scale."

In his latest research, Hebblewhite collaborates with scientists around the world to determine the global effect of climate change on wildlife, specifically ungulates such as elk and caribou.

He's excited to be working on the project with UM ecologist and fellow forestry Professor Steve Running, a pioneer in satellite imaging, who shared the 2007 Nobel Peace Prize for his work on climate change.

"It's one of the great things about being here (at UM)," says Hebblewhite, "because he's such a global thinker.

"I think our job as scientists is to help the public understand what's happening," he adds. "Myself and scientists across the world are developing data sets on elk and caribou to see how populations are responding to climate change. We'll try to design a prioritization scheme to help us predict what's happening.

"It's our job to demonstrate if climate change affects wildlife dynamics and to figure out how to protect and restore habitat. It may help people work on solutions." V

A group of caribou females and calves spotted during an aerial winter survey in Jasper National Park.

(Right) Mark Bradley, Boreal Nature Photos. (Top) Mark Hebblewhite photo.

For more information, e-mail mark.hebblewhite@umontana.edu.

Though she normally studies osprey, UM senior Anicka Kratina-Hathaway in this case holds a rough-legged hawk as part of a banding and migration study.

All photos by Erick Greene

Young researcher studies raptors impacted by metal contamination

By Caroline Lupfer Kurtz

Senior Anicka Kratina-Hathaway's academic career is a perfect example of the value of being ready and willing to seize opportunities whenever and wherever they arise. Kratina-Hathaway — her maternal grandfather was Czech — was born and raised in Montana, growing up in Miles City until her family moved to Missoula when she was 15. As a UM sophomore, she spent a year in France at the University of Nantes, studying literature and history. She now is enrolled in the Davidson Honors College, where she majors in organismal biology and minors in French. She has received funding three times from the Montana Integrative Learning Experiences for Students (MILES) program of the Howard Hughes Medical Institute, which supports undergraduate research experience. Her thesis project, under the aegis of UM biology Professor Erick Greene, is on reproductive success of osprey in Western Montana and includes some of the first data on heavy-metal contamination of osprey as a result of bioaccumulation through the food chain. Her research presentation won first prize in life sciences at UM's 2008 Undergraduate Research Conference, and she traveled with other students from the honors college to a national undergraduate research conference in Flagstaff, Ariz., last April.

Q: How did you get started on this research path?

A: As a freshman, I took an introductory biology course, and Erick Greene taught a portion of it. It was fantastic; very exciting. That was a huge lecture class, though, so he didn't really know who I was. I introduced myself again while ringing up groceries at the Good Food Store, where I was working as a cashier for a while; then I basically kept bothering him to get involved with a research project. I wasn't looking for osprey research in particular. I think I was hoping he'd let me come along on one of his projects in the Amazon or something, but it really doesn't matter. I could be studying newts and be having a great time. I just love fieldwork.

Q: So this is your first time studying birds?

A: Not really. I had done a little work previously on songbirds in Arizona through (UM researcher) Tom Martin's project, and I volunteered a little bit on some owl research around Missoula.

Q: What does the osprey project entail, exactly?

A: Surprisingly — since ospreys are such familiar birds here — there's no long-term data on their reproductive success in Western Montana. This means the number of eggs laid in a season, how many hatch, how many chicks fledge or leave the nest. Eggs begin to hatch in late June; we gathered blood and feather samples in mid-July and banded a number of chicks as well. The bands will help track these birds through their migrations and give us some basic natural history information, like where they choose nest sites and how long they live.

The blood samples are to give us a picture of mercury and other heavy-metal contamination — in the birds and in local streams and rivers — as a result of eating fish from waterways that have been impacted by runoff from past mining projects.

A cool thing about this project is that we were able to involve a number of local kids through summer camps at the Montana Natural History Center and the Flagship program. We met kids at the camps and gave presentations on the project and osprey natural history in general, then took them out to meet Erick or Rob (Domenech, with Raptor View Research Institute) or Heiko (Langner, with UM's

UM researchers and students use a boom truck to return an osprey chick to its nest near Missoula. (Kratina-Hathaway is far right)

Environmental Biogeochemistry Lab). They'd have a cherry picker to take them up to a nest, bring a chick down to show the kids, get the samples and then return it. It was a pretty neat way to get kids into science and spread the word about osprey. I also got to go up in the bucket truck and collect a couple of blood samples — my first experience doing that— and weigh birds and so on.

Q: Did this bother the ospreys at all?

A: It seems ospreys are pretty tolerant of human activity. We would take all the chicks from a nest at once, and the female would be pretty agitated. But she'd get right back on the nest after we'd backed the truck away once we were done.

Q: Did you always want to be a scientist?

A: I really like field research; that's what I want to do. When I was younger, I was into marine biology and mammals, but now I'm open to anything. I'm very interested in politics, as well, and was president of the Young Democrats in high school. Two of us got to go to D.C. in 2005 to protest the inauguration. We'd been given tickets and, because we were young, enthusiastic faces, we ended up closer to the front than we expected. When President Bush came out to speak, our protest was to stand and turn our backs. I was amazed at the reaction. Ladies in fur coats screaming at us; I couldn't believe the language they were using toward kids. It was probably the coolest thing I've ever done. We had a lot of fun in Washington, and I'd maybe like to end up doing some combination of environmental policy and international work someday.

Q: What about immediate future plans after graduation?

A: I probably won't finish up until January 2010. Then I'd like to take a break, do some international volunteer work with the Peace Corps or another organization; then come back and go to graduate school someplace other than Montana. I've always been interested in different places and cultures. And I know it sounds cliché, but the idea of the Peace Corps, of giving back, is very important to me. It's another way to expand yourself as well, meet new people, make more connections. And with the Peace Corps I could use my biology degree.

Q: What do you like most about what you're doing right now?

A: I love the chance to meet and work with so many different people, and that one thing leads to another. You work with one person, who introduces you to another and so on, and you get to learn so many new things. Plus, right now I'm working with the guidance of Erick Greene, a big "guru" on campus. He's involved in so many different projects and is so great about involving students, giving them credit. I'm very fortunate.

Q: What is the hardest or most challenging thing for you right now?

A: I guess the biggest bummer is that as you get farther along in education, you have to make choices. You can't go in every direction you'd like. Plus, you get busy and stressed and need to do things like find a job to support yourself, which takes up time you'd rather have in the field! V

Kratina-Hathaway describes her research to children at a Montana Natural History Center camp.

Photo by Stefan Ekernas

UM's Vanessa Ezenwa studies parasites that afflict social ungulates such as this Grant's gazelle in Kenya.

Doubly Blessed

Wildlife biologists snare two prestigious grants

By Ginny Merriam

When mountain white-crowned sparrows leave their breeding grounds high in the Sierra Nevada during an April snowstorm, scientist Creagh Breuner can tell you why – at the biochemical level.

Sure, she says, snow covers the insects and seeds the sparrows are eating, and common sense drives them to fly lower to wait out the weather. But inside the birds, stress hormones called corticosterone are circulating and interacting with proteins to create a complex dance with their body condition, weather and the availability of food to make sure the species goes on.

It's all food for thought and investigation for Breuner, a field endocrinologist who teaches in UM's Organismal Biology and Ecology Program, as well as in the Wildlife Biology Program.

"I think about interactions between an animal and its environment," Breuner says. "What are the behavioral decisions? Then what mechanisms underlie the change in behavior? I put my endocrinology background under this framework."

For the past 12 springs – with one exception, the April in which her now-4-year-old twin boys were born – Breuner has camped at 7,000 feet and studied white-crowned sparrows at 9,000 to 10,000 feet in the Sierra Nevada near Tioga Pass. Swaddled in fleece and parkas, Breuner and her fellow researchers capture male sparrows in seed traps and place tiny 1-gram radio transmitters on their backs that are held snugly to their bodies with elastic bands around the legs. The transmitters can signal the researchers their locations in an area of 2 to 3 kilometers around the pass. The scientists also use miniature tubes implanted in some of the birds, some loaded with stress hormone doses and some empty.

So far, the intriguing results show that generally the presence of the stress hormone moves the sparrows away from breeding – they leave the breeding grounds more readily in bad

Research by UM's Creagh Breuner suggests a stress hormone reduces the chance this mountain white-crowned sparrow will breed.

weather, and they're slower to return. The corticosterone is saying to the bird, "Go away from here. Take care of yourself. Don't worry about breeding."

"So one of the things I'm thinking about is the conflict of testosterone and corticosterone," Breuner says. "I think of it as a balance between self-maintenance and breeding."

The researchers also have found that the magnitude of the corticosterone response is related to the body condition of the birds. The birds with lower fat levels seem to generate more of the stress hormone than birds in better condition, which may motivate them to leave the breeding ground more readily.

But there's much more work to be done surrounding the relationships among birds' conditions, weather and how much food is available. The end knowledge will give scientists much information about what determines fitness, or reproductive success and survival, in animals.

"How does this stress response benefit the animal in terms of fitness?" Breuner asks.

The work has implications for humans, too. Biomedical work looks at the ties among the level of stress in an individual's life, how the individual responds and the level of heart disease, Breuner says. And the work also speaks to conservation biology, where scientists look at hormone levels to read stress responses to changes in the environment.

"So I'm looking at the variations among animals and birds," she says. "I am absolutely interested in the basic biology. That's what drives my work and drives my interest."

At home, it's no surprise that Breuner's twin sons read "The Sibley Guide to Birds" and accompany their parents on fieldwork. Breuner's husband, Art Woods, also is a UM scientist. The couple left the University of Texas at Austin for Missoula two years ago because UM had positions for both of them.

"I'd never really thought about Montana," Breuner says. "I came up to visit for my interview and loved it. I'm so glad we're here. I love our neighborhood, I love our house, I love our colleagues. It's perfect."

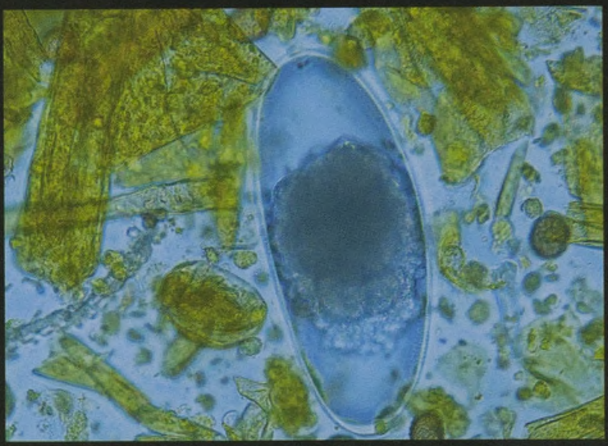
That good experience was rounded out last winter when Breuner won a National Science Foundation Early Career Development Program grant of $800,000. The five-year grant will enable her to pay a full-time postdoctoral student, pay Breuner's salary during the summer and also support her laboratory.

"I was blown away to get that level of award," she says. "It's an honor."

And UM was doubly blessed. Vanessa Ezenwa, a UM scientist who works in wildlife disease ecology, also recently won an Early Career grant, bringing in $715,000.

The dual honor is astonishing, says Dan Pletscher, UM professor and director of the Wildlife Biology Program.

"I don't know of any other case anywhere where such a thing has happened," he says. "I think it's an example of the incredible quality of people we can attract to this university."



Creepy critter: This strongyle worm is found in the gut of Grant's gazelles.

Ezenwa, who earned her master's and doctoral degrees at Princeton, is interested in the relationships between levels of parasite infection and infectious disease in wild animals. She looks at the way the social organization of an animal population affects parasitism and the transmission of disease.

"I'm interested in social behavior – why animals are organized in different ways," Ezenwa says. "What makes animals live singly or in groups? Travel or not? And what are the factors that affect the ways animals behave?"

Ezenwa's scientific interests are so diverse that she sometimes has to put the brakes on. As an undergraduate biology major at Rice, she took a course in animal behavior and worked in the lab of an animal behavior scientist. That work set her on the path of disease ecology.

"I realized people did that," she says. "But, you know, you never connected that those people on 'National Geographic' do that for a job. We can understand why animals do things. And we can look for underlying mechanisms for why animals do what they do."

Ezenwa's work began by studying the benefits and detriments of living in groups, with a focus on ungulates. She says groups can protect themselves from predators and forage for food together, but they also bring a greater risk of disease transmission.

The class of an individual also matters, she says. Some male Grant's gazelles, for instance, defend a high-quality piece of territory, and once they've secured it, they don't leave. These males have higher levels of parasite infection than females or lesser males. In Ezenwa's study, she asks what effects the parasites are having on these male gazelles.

"That's the interesting question," she says. "What are the lasting effects? How are these parasites affecting their behavior and their fitness?"

Ezenwa has looked at worm infestations in the gazelles in Kenya, where she has worked for the past nine years. Her newly funded research has three parts: observing what the animals do in the field, capturing the animals and treating them for the parasites, and looking at the animals' hormone levels.

"Then you can answer questions like, 'When you take these parasites away, do males spend more time mating females and defending their territories?'" she says. "Maybe it's the high levels of stress hormones that cause the high rate of parasite infection."

Ezenwa also works in South Africa with the African buffalo, where she looks at the relationship between parasitic infection and bovine tuberculosis. That work has implications for the human population.

In developing countries, HIV tends to progress faster and be more severe among humans. There's also a high level of parasite infection in people.

"There's a lot of evidence coming out now that the presence of worms affects the severity of diseases like TB and HIV," Ezenwa says.

Some of that could be the result of cross-talk between the two branches of the immune system, she says.

"So if your immune system is responding to worms, it's biased toward that, and it might not respond as well or as quickly to a disease like TB," she says.

In a changing world, Ezenwa's research can inform the decisions made in wildlife management. Ezenwa's new grant will allow that work to continue.

"I am very happy, for sure," she says. "It will allow the testing of some interesting questions that are really exciting for advancing the fields of ecology and animal behavior." V

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Photo by
Stan Pagacz

Hare Today, Gone Tomorrow?

The snowshoe hare may become a climate change poster child

By Deborah Richie Oberbillig

On an unseasonably warm May afternoon, UM wildlife biology Professor Scott Mills treks into the shadowy forests above the Seeley-Swan Valley in pursuit of his quarry. He skirts the rivulets of water melting from snow patches. In one hand he holds an antenna and in the other a receiver that's picking up signals from a radio-collared snowshoe hare. The beeps increase in volume as he draws nearer. Mills picks his way over downed branches, steps out from behind a western larch and spots the white hare crouched on the bare brown earth.

"That's just an embarrassing moment for a snowshoe hare to think that it's invisible when it's not," says Mills with a grin, quickly adding that seeing such mismatched colors is becoming all too common and disturbing.

For the past decade, Mills has directed teams of biologists and students to investigate snowshoe hares on more than 35 study sites in Montana, Wyoming and Washington, including just outside UM's back door near Seeley Lake. His findings have led to improved forest thinning practices that maintain patches of dense trees for hares. He's delved into population dynamics and genetics of hares in their southern range. His research has turned directly to lynx, too, as a key predator of snowshoe hares and a threatened species.

Increasingly Mills and his students have noted an exceptional number of white hares on brown earth. Radio telemetry data revealed spring and fall to be the most deadly seasons for hares and a bonanza for predators.

"I'm speculating that the reason they are dying more in the spring and fall is because of the mismatch of colors," Mills says.

That leads Mills to the "sexiest part" of snowshoe hare research — how they respond to climate change. While a warming planet affects all wildlife, a cute white hare has the makings of the next version of the polar bear as poster animal for global warming.

Will hares continue to shift coat colors on cue regardless of the presence or absence of snow? Will this drive them to extinction? Or will they be able to adjust their seasonal pattern in time to fit new conditions?

"Climate trends for mountainous areas clearly show that while snow levels may vary from year to year, the number of days with snow on the ground is decreasing," Mills says.

Snowshoe hares evolved with plentiful winter snow in the boreal forests that form a swath across Alaska and Canada and dip down into the lower 48 states. In winter, they grow long white guard hairs to match the snow. In summer, they shed white for mostly rusty brown coats to blend with trees and soil. They depend on their cryptic coloration to hide from predators that include lynx, coyotes, foxes, wolves, pine martens and birds of prey. A hare that's the wrong color stands out like the emperor in his new clothes.

The signal for a hare to shift coat color comes from the pineal gland in the brain that senses changes in daylight length. Shortening days of autumn trigger the coat color change from brown to white. (People also have pineal glands that produce melatonin, the hormone that affects our waking and sleeping patterns and responses to seasonal day lengths.)

Like most subjects in science, the deeper you delve, the more complexities you find. Mills points out that in the Cascades, some snowshoe hares stay a mottled brown and white year-round. In the Olympic Mountains of Washington, snowshoe hares never turn white. Does this suggest some ability to evolve in response to temperature changes? If so, how quickly?

To find out, Mills will add an intensive genetic component to his fieldwork, teaming with the University of Porto in Portugal, where scientists are sequencing the rabbit genome. Together they will analyze the genetic drivers of coat color change. Mills will start with his core research areas and then expand his studies to compare coat color genetics as well as synchrony of hare cycles in southern versus northern ranges.

Mills isn't starting from scratch. He and his team have collected genetic samples from thousands of hares and several generations for the past eight years. On a typical field day, they rise before dawn to check the 80 "have-a-heart" live traps that they've

Photo by Ellen Cheng

Into the Wild: UM wildlife biology Professor Scott Mills penetrates deep into the snowshoe hare habitat of Glacier National Park. (Preceding page) A snowshoe hare in Washington's Olympic National Park that Mills studies because this population doesn't turn white with winter.

Undergraduate student researcher Kevin Sterling gently cups a newborn snowshoe hare about to receive a tiny radio-transmitter to track its survival.

Photo by Scott Mills

baited with alfalfa and apple. The traps are placed in prime snowshoe habitat such as moist forests of larch, lodgepole and Douglas fir with dense brush and overhanging branches.

Finding a hare in a trap calls for prompt action. Mills describes the process that has become routine. First, you put a pillowcase over the entrance to the trap, so the hare will run in. You keep the hare in the pillowcase while you weigh it, add an ear tag and take a tiny plug of tissue from the ear. That tissue contains DNA and is placed in a special vial. You also check the sex and assess the hare's general health. You might add a radio collar as well, depending on the project. The whole procedure takes a matter of minutes.

Snowshoe hares seemed like a natural choice for study soon after Mills arrived at UM from the University of Idaho in 1995. They're a local species with excellent opportunities for delving into their ecology and introducing students and the public alike to fieldwork. Hares also are known for a classic predator-prey relationship with the lynx. The two species are so closely associated that they even share a key attribute for winter living — thick furry hind feet for bounding atop snow.

Across Canada, snowshoe hares follow a synchronized population cycle of 10-year highs and lows. Hare numbers in the Yukon can peak at 200 to 300 per square kilometer and then drop to about seven. Lynx follow a cycle that's just slightly behind the hares. When lynx numbers are down, hares start to go up. The more hares, the better the lynx do until finally the lynx drive the hare populations down again. Mills' work has proven that those cycles are dampened in the southern range because hares don't have the same vast, dense boreal forest, thus hares never reach the high peak counts. As their numbers rise, they disperse into habitat openings, where they become easy dinners for waiting predators. In Montana and other parts of the southern range, forests tend to be patchier naturally, with added challenges for hares from logging and thinning.

Today, as a result of Mills' studies comparing survival rates in experimentally thinned forests, Plum Creek Timber Co. now leaves patches of unthinned trees to benefit hares, and in turn lynx. His research has translated directly into useful management, a result that Mills always aims for and advocates in his widely used 2006 textbook, "Conservation of Wildlife Populations, Demography, Genetics, and Management."

Until now, the lynx-hare relationship has proved Mills' most high-profile research. After the U.S. Fish and Wildlife Service added lynx as a threatened species in 2000, his phone rang with calls from the National Park Service and timber companies alike on how to manage forests for lynx health. Mills' subsequent studies led to findings that lynx are highly mobile in their southern range. One cat might travel 1,000 km (620 miles) in a season.

"Conserving where lynx are now is important, but it's also important to conserve the places in between because lynx may move into those places as well," Mills says.

Taking the next leap to examine snowshoe hare response to climate change is both a natural progression and an exciting new phase in his long-term research.

"Wildlife will either move, adapt or die in response to climate change," explains Mills. "The study becomes important because we need to know how much natural selection will help animals deal with climate change that is happening at a very fast rate."

That knowledge in turn will help managers focus their efforts to save species through such actions as conserving movement corridors from south to north.

"Hares are important because they are prey for almost everything in the forest that eats meat," Mills says. "Without hares, the ecosystem unravels." V

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Troubled Trout

Projects tackle dams, invaders, hybrids and more

Cutthroat trout photo by Magnus McCaffery

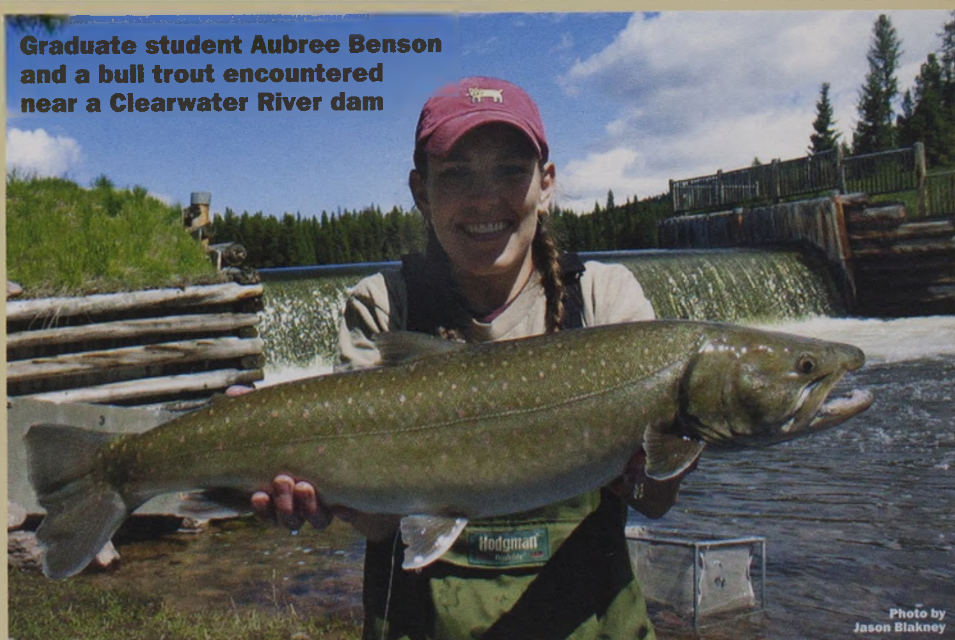
By Kim Todd

A 1929 issue of Montana Wild Life, the magazine of the State Fish and Game Commission, included a picture of a bull trout under the caption "The Cannibal of Montana's Streams." The photo shows a trout sliced open to display 103 fingerlings that were in its belly when it was caught near the mouth of Rattlesnake Creek. Another article declared bull trout "the enemy of game fish" and described efforts to scoop them out of Flathead Lake to give smaller fish a chance.

Times have changed.

Now the bull trout is listed as "threatened" under the Endangered Species Act. In most Montana lakes and streams, anglers are required to carefully release them back into the water. And Lisa Eby, associate professor of aquatic vertebrate ecology in UM's College of Forestry and Conservation, is looking at ways to help bull trout and other native fish thrive.

Eby says fisheries science has come a long way from its beginnings when hatcheries viewed rivers as empty channels that could hold some ideal assemblage of fish, a view she characterizes as "the Walt Disney World approach."



Graduate student Aubree Benson and a bull trout encountered near a Clearwater River dam

Photo by Jason Blakney

"Our perceptions and our values have changed," Eby says, adding that the new emphasis is on "an appreciation of the native systems and the native trout." Arctic grayling. Northern pikeminnow. Pallid sturgeon. All have risen in esteem, as have other native species, such as the frogs and toads of Montana showcased in a color poster on Eby's office door.

Many threats to Montana's wildlife are large and well-known — climate change, habitat fragmentation, polluted waters. But small changes to the landscape — an earthen dam built for irrigation, a newly closed road, a beaver pond — can have large ramifications, too, and Eby and her graduate students have set out to quantify them.

One study in Eby's lab looks at effects

of small dams. Many of the more than 2,000 small dams in Montana no longer serve their original purpose or are showing their age. Built to last 50 or 100 years, many are reaching the end of their life spans, forcing the state to decide whether to repair or remove them.

Outside Seeley Lake, graduate student Aubree Benson tracks bull trout near two dams on the Clearwater River, a tributary of the Blackfoot. Migratory bull trout are born in creeks and streams, move to lakes where they bulk up, then return to their birthplace to spawn. Benson has radio-tagged bull trout, surgically injecting tiny transmitters that put out unique signals every two seconds. This way she can track individual fish and see whether the dams thwart migration.

Benson also snorkels the river bottom to see if bull trout gather below the dams, and she set up a fish ladder that leads to a tank where she can monitor which fish are trying to get over. The goal of the project, done in collaboration with Montana Fish, Wildlife and Parks, is to determine if the dam has a negative effect on the survival of bull trout populations.

Conventional wisdom says that removing dams helps fish, but Eby suspects that may not always be the case.

Just as attitudes toward bull trout have swung 180 degrees, so have attitudes about non-native fish. Eighty years ago, Montana Wild Life articles described heroic rescues of exotic sunfish from pools that dried up in the summer and schemes to increase numbers of non-native bass and northern pike. In the 21st century, as these newcomers have disrupted ecosystems and battered native trout populations, the question is how to stop their spread.

Some dams have kept northern pike — voracious predators of young trout — downstream. At Hungry Horse Dam near Glacier National Park, the barrier has prevented lake trout (native to the Missouri River but not the Flathead River) from reaching the reservoir.

"It's one of the places the bull trout are thriving; the cutthroat are thriving," Eby says. "If your dam is holding back a lot of exotics ... it might not play out that all dams are always bad."

The study on the Clearwater will outline the trade-offs of taking down the barriers or leaving them in place.

Another of Eby's graduate students examines different kinds of small-scale dams — those made by beavers. When beavers fell trees and build a dam, they create pools that are warmer and more biologically productive than surrounding, free-flowing waters. Because of this, beavers will sometimes be transplanted to help restore a damaged watershed.

But there is a downside. "A lot of people have noticed that brook trout will move into an area where beavers have established," Eby says.

Brook trout, native to eastern North America but not Montana, out-compete native westslope cutthroat at lower elevations. Westslope cutthroat are stuck at the top of drainages, where the water is colder and there are fewer insects to eat.

In Beaverhead-Deerlodge National Forest in Southwest Montana, Magnus McCaffrey compares watersheds with beavers to watersheds without. He captures brook trout and cutthroat at the start of the summer, marking them with tags — 8 mm transponders with individual codes. He then recaptures them several months later, scans the tags to determine the identity of the fish, and tallies growth and survival rates.

McCaffrey's study is designed to see whether beaver dams let brook trout gain a finhold higher in the watershed and if there is anything managers can do about it.

A third project looks at westslope cutthroat in the Jocko River, just north of Arlee. As if westslope cutthroat didn't have enough problems with brook trout, they also have trouble with rainbows. Before stocking, rainbows and cutthroat only co-existed in a few watersheds in Western Montana and their breeding schedules kept them from mating. But rainbow trout that have been stocked in traditional cutthroat areas interbreed with them and produce fertile offspring.

Right now small dams along the river keep the hybrids from entering some streams. Working with the Confederated Salish and Kootenai Tribes, graduate student Matthew Corsi mapped the location of hybrids along the Jocko. He's now comparing hybrids to pure westslope cutthroats, looking at the timing of migration, measuring how large they are as 1-year-olds and counting eggs to measure fecundity.

"Are they less fit? Do they respond differently? It's an unknown now," says Eby. Answers to these questions might point to whether hybrids should be kept out or let pass as if they were pure cutthroats. "If you pass fish that look like cutthroats, what is the long-term sustainability versus what are the genetic consequences?" Eby asks.

These studies center on questions raised with increasing frequency in Montana and throughout the West. How do you conserve native species in the face of constant competition for water and the influx of invasive species?

"Everyone in the lab, whether they are working on amphibians or fish, are looking at how landscapes or riverscapes affect fish populations and communities to give us more information to solve some of these contemporary problems," Eby says.

Wildlife managers are as eager to know the answers as the scientists. As Eby says, "They're interesting questions not only from a biological point of view, but they're useful, too." V

For more information, e-mail lisa.eby@umontana.edu.

Trout photo by Aubree Benson. River shot by Lisbet Johnson.

(Left) A male bull trout in the Clearwater River. (Right) UM doctoral student Magnus McCaffery, bottom, and field technician Dan DeSloover electrofish in Johnson Creek.

Cracking a Mystery

Research suggests inattentive bird parents prod

By Jeremy Smith

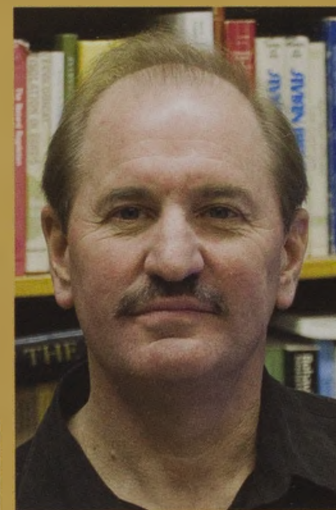
Wildlife photos by Thomas Martin

Both the spotted barbtail and blue-gray tanager are tropical songbirds native to Venezuela. One weighs, on average, 16.5 grams. The other weighs 32.5 grams. Why, then, does the much smaller species — the barbtail — bear eggs nearly 10 percent larger?

e larger eggs

This Andean solitaire thrush, found in the Venezuelan rainforest, has larger eggs than its counterparts in more temperate regions.

Photo by Brian Schwartz



UM researcher Thomas Martin has become adept at locating the nests of the songbirds he studies, such as that of the plain antvireo (top) and a hummingbird. Both nests were found in the tropical rainforests of South America.

This question led Thomas Martin, assistant leader of UM's Montana Cooperative Wildlife Research Unit, to a surprising discovery: At least in birds, parental neglect may require the parents to invest more energy in eggs to produce stronger, healthier offspring.

For most animal taxa, Martin explains, egg size and offspring number are inversely related: Bigger eggs mean fewer offspring; more offspring mean smaller eggs.

"The classic theory is that long-lived things put more energy per offspring to increase the quality of that offspring," he says. "The idea was that they're putting more energy into each young."

Scientists long believed that comparisons of tropical and temperate songbirds supported this explanation because tropical songbirds generally bear fewer but larger eggs than their northern counterparts.

"From long-standing theory, it has just been assumed that this reflects that trade-off," Martin says. "But people didn't look deep enough."

Refuting the theory of a quantity-versus-quality trade-off are examples such as the barbtail and the tanager. Each tropical species produces the same number of offspring — two. Yet average egg size in relation to body mass is dramatically smaller in the tanager, a seeming anomaly repeated across dozens of different tropical species comparisons in Martin's data sets.

"The truth is, in the tropics most bird species have little variation in the number of eggs they produce," he says. "Most species produce two eggs. So you've got a relatively invariant number of eggs, yet egg size varies dramatically across those species."

Addressing this enigma required more than a decade of on-the-ground observation by Thomas and his field teams in tropical Venezuela, subtropical Argentina and north temperate Arizona. Within and among those regions, he discovered that differences in parental care — far more than fertility or any other factor — explained which species produced relatively larger offspring.

But the trend line runs opposite to what one might anticipate. The less time and attention parents provide their eggs, Martin found, the relatively bigger each member of their brood will be.

When parents leave their nests for long periods, it significantly lowers the temperature of their eggs. Lower temperatures, in turn, mean longer embryonic periods. Not unlike hibernation, this deferred birth date requires that eggs be provisioned with more energy — literally bigger yolks and greater albumen. Hence the eventual larger offspring.

"One of the things many people don't really realize, including many scientists, is that birds are actually ectothermic as embryos — they rely on the parents to provide the heat by sitting on the eggs," Martin says.

In addition, birds are extremely hot-blooded, with an average body temperature of about 40 degrees Celsius (104 degrees Fahrenheit), he says. Each minute parents spend off the nest, therefore, has the potential to slow embryo development dramatically.

"The ambient temperature at the elevation where we work in Venezuela only gets up to 25 degrees Celsius and drops to 15 Celsius at night," Martin says. "Even at its maximum, it's still much colder than the optimum."

Nonetheless he found that parents in the tropics sit on their eggs for shorter periods than in the temperate zones.

"The fact that the tropical birds spend less time on the nest means that, even though the tropics are warmer, the eggs are actually experiencing colder temperatures than their counterparts in the temperate regions," Martin says. "It's the opposite of what you might expect."

Martin first came to the topic in an effort to understand how such differences in temperature affected the rate of embryo growth. When he realized colder eggs would cause embryos to use more energy, his next thought was to study the possible effects on egg size.

"If they need more energy, they have to be larger," he says. "So I would expect species that let their embryos get particularly cold to need even larger eggs."

Such is the case of the spotted barbtail, "a little guy," as Martin describes the species, but one with relatively enormous eggs. Field teams observed every day that barbtail parents take a four- to five-hour foraging recess from the nest. Within minutes, eggs drop to ambient temperature — about 20 degrees Celsius.

"That's about half of the optimum range," Martin says, "and it's going to sit there for four to five hours at that temperature until the parents get back on."

He contrasts this situation with that of the blue-gray tanager, whose parents seldom leave the nest for more than 40 minutes. "Average egg temperature is much warmer for the tanager than for the barbtail," Martin says. "So the tanager can survive with a smaller egg size."

Of 36 species studied in Venezuela, the barbtail had the longest incubation period at 27 days. By contrast tanagers hatched after 14 days.

What's especially exciting about Martin's novel embryonic temperature hypothesis is its ability to explain egg-size variation not only within the tropics but also between latitudes.

"The traditional theory is that development is slow in the tropics because that allows enhanced development of intrinsic qualities like neural development and immune functions, which enhance longevity," he says. "Some of that theory is true, but there's a lot of variation that's explained by temperature caused by parental behavior. I'm arguing development is slow in the tropics because parents [spending more time off nest] are allowing their embryos to experience these cold temperatures."

Earlier this year the Proceedings of the National Academy of Sciences accepted for publication a paper by Martin explaining his new theory and the data that supports it. This follows another major publication last year in the journal Ecology about how climate change affects the ecosystem of his longtime north-central Arizona study site — a 20-kilometer area near the edge of a long, steep slope that forms the southern border of the Colorado Plateau.

"My research is two-pronged," Martin says. "One is looking at all the long-term components of this major ecosystem and how they work together and how they're affected by things like climate change and resource management. The other prong is trying to understand wildlife demographic and reproductive strategies across the world."

He'll explore another avian mystery next year when research begins at a new field site in Borneo's Kinabalu National Park.

"Birds in tropical South America and tropical Africa have similar clutch sizes — generally two eggs," Martin says. "Asia is completely different. Most of those species have three or four eggs. The little information we have suggests that they develop very fast but are still long-lived there, again in contrast to South America and Africa. It potentially breaks the traditional view that you have to develop slowly to be long-lived. Nobody's recognized that previously."

The umbrella organization of all cooperative wildlife research units, the United States Geological Survey, employs 10,000 scientists. Only 20 may be designated a "senior scientist" of high international stature. This April Martin was so recognized.

"I'm one of very few people in the world looking at tropical nesting biology," he says. "Early in my career, reviewers of my grant proposals would say, 'Everyone knows you can't find nests in the tropics.'" His solution? "A lot of area and a lot of training. I've always had a knack for finding nests. The trick is to then train other people to do that."

Recent successes, he says, only make him impatient to return to the field.

"I'm running out of years to start a new project," Martin says with a laugh. "Both the Argentina and Venezuela study sites were in the Andes. In Borneo, it's Mount Kinabalu, which is a very steep mountain. Running up and down these mountainsides is getting harder."

A chlorophonia songbird nesting in the Venezuelan rainforest

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White-eye bird photo by Thomas Martin

"All things are connected like the blood that unites one family. Man did not weave the web of life, he is merely a strand in it. Whatever he does to the web, he does to himself."

— Attributed to Chief Seattle (1786-1866)

Above: Anicka Kratina-Hathaway, a UM senior in organismal biology, carefully holds one of her research subjects, an osprey chick.

Photo by Erick Greene

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